RE-ORDER NO. 65-279

FINAL TECHNICAL REPORT

ON

ELECTROSTATICALLY DRIVEN

CAPACITOR PROJECT

PREPARED FOR

JET PROPULSION LABORATORY
4800 Oak Grove Drive
Pasadena, California

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Administration under Contract NAS7-100.

Purchase Order AV3-21406

And

Contract No. 950668

May 5, 1964

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1 of 64

J. Greenfield

KINELOGIC CORPORATION

REPORT

[redacted]

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TECHNICAL PROGRESS REPORT
ON
ELECTROSTATICALLY-DRIVEN CAPACITOR PROJECT
FOR
JET PROPULSION LABORATORY

I. STATEMENT OF PROGRAM PURPOSE

Development of an electrostatically-driven capacitor, together with its drive circuitry for electrometer applications in space instrumentation in accordance with JPL specifications XSS-30028-DSN.

II. REFERENCES

Purchase Order AV3-21406 dated April 22, 1963
Contract #950668 dated July 8, 1963

FINAL REPORT

III. SUMMARY

a. Work done during this period

1. Operation of the Ames transducer was experimentally verified and results showed that the same principle was feasible in a dynamic capacitor for electrometer applications on spacecraft.
2. Theoretical expressions for the static values for capacitance, electrostatic force and conversion efficiency were obtained for use in preliminary design.
3. A first experimental unit was built to check out the electrostatic drive principle on membranes which indicate that the specs could probably be attained.

4. Technology of adhesives, solders, special tooling methods of ultrasonic cleaning and machining were worked out in preparation for the first pre-prototype.

5. Means for picking up the vibrations of the diaphragm by an electromagnetic coil were developed and tested with satisfactory results.

6. Various methods of attaching the diaphragm to the case were attempted, using screws and epoxies. Stretching tools were utilized in the securing process.

7. The first two preprototypes were constructed and tested and found to give predictable results for resonant frequency based on Timoshenko's thin plate formula.

8. More stable frequency and conversion efficiency were obtained by using thicker membranes, in the order of 15 mils, rather than 2 or 3 mils. An edge-supported diaphragm of this type was used on Engineering Model 0.

9. Techniques of measuring conversion efficiency, contact potential and insulation resistance were developed, and initial tests at room temperature indicated results close to specs.

10. A drive oscillator for the dynamic capacitor was designed, built on a breadboard, tested with the unit and found to work satisfactorily.

11. Golding of the metal surfaces of the dynamic capacitor was attempted first on prototype No. 2.

12. A center supported design was worked out after it was discovered that there was drift of resonant frequency and conversion efficiency with temperature with the edge-supported diaphragm. Initial tests on an experimental unit showed good results.

13. Techniques of heliarc welding, use of feed-through insulators instead of a large sapphire disc, and methods of cleaning and outgassing were perfected.

14. A redesign of the magnetic pickup was necessary on prototype No. 5, the first unit using the new center supported design.

15. Timoshenko's thick-plate formula was verified in predicting resonant frequency of the new center supported units. Diaphragm thicknesses in the order of 12 mils were used.

16. Stability with time and temperature of conversion efficiency and resonant frequency was obtained with the center supported diaphragm of the dynamic capacitor.

17. Contact potential was brought within specs as a result of continuing work on the golding process and techniques of neutralization cleaning and outgassing.

b. <u>Significant Findings</u>

1. The Ames transducer served as a basis for determing the feasibility of the dynamic capacitor, but it was found impractical to use very thin membranes in this unit.

2. The first edge-supported unit used a 15-mil diaphragm with 1-mil spacing between plates and operated at a resonant frequency of about 5000 cps and was within specifications on conversion efficiency and driving voltage at room temperature.

3. The oscillator circuit developed for the dynamic capacitor required a free-running multivibrator to insure suitable self-starting characteristics.

4. Timoshenko's thick plate formula serves as a good guide in predicting resonant frequency of diaphragms in the range from 10 mils to 15 mils thickness.

5. Golding of the diaphragm and pickup anvil reduces the contact potential but extreme care must be taken to keep the gold plating bath pure, and in cleaning the capacitor after assembly.

6. Great care must be exercised in selection of metals for the capacitor. NiSpanC was successful as the diaphragm metal and other metals had to be selected which corresponded with the thermal expansion coefficient of this material.

7. With the clamped membrane, conversion efficiency increased as the temperature decreased, and the resonant frequency increased with increasing temperatures. These instabilities led to a change in design to the center supported membrane.

8. With the center supported diaphragm, it was found that excellent stability could be achieved with both conversion efficiency and resonant frequency over the specified temperature range. An aging period of about one week is required.

9. Heliarc welding proved to be a much superior seal to epoxy. It also made the outgassing problem simpler.

10. Best magnetic pickup design was obtained by mounting the coil near the outside of the diaphragm and taking advantage of the variable air-gap reluctance.

11. To prevent contamination and speed up the outgassing process, it is necessary to flush out the unit with a base solution to neutralize any acid contaminants which may be present from soldering or other operations.

12. Flushing out the unit with hydrogen helps to rid the gold plated surfaces of oxides which may have formed.

13. The case should be loosely mounted to the support structure and the leads should be kept light and short to prevent coupled resonances and damping to the dynamic capacitor.

c. <u>Statement of major problems encountered and their solutions</u>

1. With the use of thin diaphragms in the order of 2 or 3 mils thickness, resonant frequency and Q was dependent upon the peripheral tension which was very difficult to control.

   <u>Solution</u>: Went to a thicker membrane and used a stretcher tool.

2. The drive frequency had to be one-half the resonant frequency of the membrane, making it very difficult to use positive feedback on the oscillator.

   <u>Solutions:</u> (a) Use a half-wave rectifier in the output; or,

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(b) place a series polarizing voltage in series with the a-c drive. The latter method was adopted.

3. When the NiSpanC diaphragms were made 10 mils in thickness or greater, it was found that Timoshenko's thin plate formula no longer applied.

Solution: Use his thick plate formula, which proved a satisfactory guide on both edge-mounted and center-supported diaphragms.

4. Difficulties developed in the use of sapphire insulators due to surface contamination and leakage at feed-through points.

Solution: Use feed-through insulators of special design and construction.

5. A continuing problem of contamination existed throughout the program in varying degrees. Particles of metal or lapping compound would get into the space between the diaphragm and one of the anvils. Epoxy and soft soldering caused oxides to form and gases were diffused into the surfaces of the metals. Acids and oxides were present in the unit.

Solution: Use clean room, exercise great care in lapping and cleaning, flush out unit with basic solution and with hydrogen and argon. Outgas the unit in a vacuum at 135 C for a period of at least two days, and preferably two weeks.

6. Instability of contact potential with temperature and time has been perhaps the most difficult problem in this project.

Solution: Avoid contamination, flush unit with hydrogen and outgas for at least 48 hours with argon until stable operation is achieved (see under Conclusions and Suggestions for Future Work).

7. It became apparent that the specifications for stability of conversion efficiency and resonant frequency with time and temperature were not being met with the best that could be done with the edge-supported diaphragm.

Solution: Support the diaphragm at the center and leave the edges free to vibrate. This does away with the constraints of variable tension along the periphery.

8. In the edge-supported design, it was a simple matter to place the pickup coil in the middle and pick up the reluctance changes in the magnetic path and generate a pickup signal for the input to an external oscillator. The shift to the center supported design left no room at the center, and it was necessary to place the pickup near the edge of the diaphragm. As a result, less voltage is presently available. Considerable effort was put into minimizing leakage paths and obtaining the most effective coil possible.

IV. TECHNICAL REPORT

a. Technical Description of the Dynamic Capacitor

The basic electrical circuit for the dynamic capacitor is shown in Fig. 1. An input signal is applied between A and G, in the form of a small voltage. An a-c drive voltage is applied between C and G the frequency of which must be the resonant frequency of the membrane. The resultant mechanical motion shown in the figure as dashed lines causes the input signal voltage to be amplitude modulated at the mechanical resonant frequency of the membrane. The output signal voltage is taken from point B and applied to the input of an a-c electrometer amplifier.

The basic mechanical construction is shown in the sketch of Fig. 2. The drive anvil, C, has a voltage impressed between it and the diaphragm, or ground G. This voltage is composed of a d-c polarizing voltage and an a-c voltage. The frequency of the a-c voltage is chosen to correspond with the resonant frequency of the membrane or diaphragm, G. Typical values of the diaphragm thickness are from 10 to 15 mils, diameter from 1/2" to 3/4" with resultant resonant frequencies from 4 to 5 Kc.

The forces which set the diaphragm into vibration are electrostatic in nature and with spacings between drive anvil, C, and diaphragm B, of from 1 to 2 mils, voltages of less than 100 volts will produce conversion efficiencies at the signal anvil of the dynamic capacitor of 10% or more. It will be noted in Fig. 2-B that the signal anvil, A, is shaped to obtain greater conversion efficiency than would be possible with a flat diaphragm. Materials such as NiSpanC have the temperature coefficient, mass and modulus of elasticity which are requisites for this application.

The unique features of this dynamic capacitor are: The use of a center-supported diaphragm as the resonating member, the electrostatic drive, and the mounting of the anvil and coupling capacitor. Detailed drawings are shown in the Appendix. These show the complete unit with drive and signal anvils, the vibrating diaphragm, coupling capacitor and magnetic pickup coil. The pickup coil can be used to provide the signal for drive oscillator in a positive feedback network.

b. Assembly Procedure for the Dynamic Capacitor

The detailed drawings are shown in the Appendix of this Report and are of three types:

1. Size C Assembly Drawings
2. Size B Sub-assemblies or housings
3. Detailed parts drawings which are referred to on the C drawings by number.

A list of the drawings and their titles is shown in Table I. These are listed in the order as they appear in the Appendix. Drawing numbers are given, together with titles and some notes of explanation.

The technical procedures required in the construction of a dynamic capacitor are given in a series of sheets following the drawings in the Appendix. There are our 38 specific operations listed. For each operation, the parts used are specified, the number per unit, material used, tools required, and storage devices needed. The remaining three columns provide a description of the processes required in sufficient detail for instruction. Methods of insuring good results from each operation are given under the columns headed "Quality Control."

c. Peripheral data generated as a result of this program

The capacitance between a pair of parallel plates with vacuum dielectric is:

$$C = \frac{0.224\ A}{d} \text{ pf} \tag{1}$$

where

C = Capacitance between plates in picofarads

A = Effective area of the interface in square inches

d = Spacing between plates in inches.

If a voltage, V, is applied between the plates, the force applied to the diaphragm is

$$F = 0.693 \times 10^{-10} \left[\frac{C\ V^2}{d}\right] \tag{2}$$

where

F = Force in oz.

V = Voltage between plates

If one considers the case for a circular diaphragm under uniform loading, which is equivalent to the application of the electrostatic force of equation (2), the deflection for an edge-mounted diaphragm can be obtained. If the deflection of the membrane is small compared to spacing, d, it is possible to get an expression for the change in the spacing, Δd,

$$\Delta d = \frac{F_{ave} \ (M^2 - 1) \ R^2}{503 \ E \ M^2 \ T^3} \text{ in.,} \qquad (3)$$

in which

F_{ave} = Average value of the applied electrostatic force
M = Reciprocal of Poisson's ratio
R = Radius of the membrane in inches
E = Modulus of the membrane material in lbs/in^2
τ = Thickness of the membrane in inches

Where a diaphragm of 5 mils thickness or less is used and it is clamped around the edge, the equation for the resonant frequency is

$$f_r = \frac{15.06}{R} \sqrt{\frac{S}{\tau}} \text{ cycles/sec} \qquad (4)$$

where

S = Peripheral tension in lbs/in

It was discovered that the control of tension was very difficult from unit to unit. Hence, it was decided to go to a center supported diaphragm. Also, thicker membranes were used. The expression for the resonant frequency for this case is

$$f_r = \frac{60,900 \ K\tau}{R_e^2} \text{ cycles/sec} \qquad (5)$$

where

K = mode constant $\approx$ 0.45

R_e = Effective radius of the diaphragm in inches

The effective radius is one-half the outside diameter of the diaphragm minus the inside diameter which is the diameter of the support structure.

Non-linear effects exist with the edge-supported and with

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the center supported diaphragms. When the oscillator frequency is swept through the resonant frequency, the manner of breaking into oscillation is different going in from the upper end as compared with going into resonance from the lower end. When the magnitude of the drive voltage is increased, the conversion efficiency does not always follow a linear relationship, as would be expected with a linear second-order resonant system.

There have been aging effects and changes of the resonant frequency and conversion efficiency with temperature which can be explained only in terms of some non-linear characteristics present in the vibrating diaphragm.

These variations might be explained with variations of either the Q of the resonator or a non-linear modulus of elasticity. The latter seems the more logical to explain the variations between conversion efficiency and resonant frequency actually noted in experiments. Certain parts of the membrane possibly become stressed beyond the region of linearity and thus cause changes in the effective value of the modulus of elasticity. These non-linearities are of two kinds: long-term and short-term. The former requires certain aging processes before the conversion efficiency stabilizes. The second does not cause distortion in the output waveform, but does affect the conversion efficiency obtained with a given applied driving voltage. Heat treatment of the diaphragm has an effect on this non-linearity, thus requiring a consistent treatment when the proper one is chosen.

In the center supported design, it is somewhat of a problem to obtain a substantial pickup voltage. When the edge-supported design was used, the pickup was placed in the center and reluctance changes gave pickup voltages of 50 millivolts without difficulty. When the center supported design was selected, several approaches were attempted. Difficulties were encountered with leakage flux and shorted turns. By minimizing these and placing the pickup coil at the outside edge of the diaphragm, it was possible to obtain pickup voltages of from 10 to 20 millivolts. It is suggested that a small transformer be used to bring this value up to the required magnitude for the oscillator input.

The problem of second-harmonic distortion in the output a-c amplitude modulated signal is a function of the polarizing voltage, drive voltage, and the geometry of the signal anvil. To minimize this distortion, the ratio and magnitudes of the polarizing voltage to a-c drive voltage must be carefully chosen and the signal anvil is lapped with an optical lens with a radius of curvature of 20 inches to provide a slight curvature around the outside edge of the signal anvil.

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The mounting of the dynamic capacitor must be such that minimal coupled energy in the operating band is taken from the unit. This requires very small, short leads and a resilient mounting to the structure.

The conventional approach of using monocrystalline sapphire was first used on the dynamic capacitor with feed-through pins to the signal and coupling anvils. However, difficulties with surface contamination and in securing vacuum-tight seals led to the use of Bendix TH10 and TH17 high alumina ceramic feed-through terminals both on the signal and drive sides. It was found later that these terminals developed leaks after the various heat and soldering processes had taken place in the capacitor assembly.

Therefore, a new method of providing for leak resistance as well as good insulation resistance was worked out together with Physical Sciences Corporation. This company has developed a method of pouring molten dielectric directly around the terminals while they are held in position by a special tool. In this way, a superior seal is obtained and one that will handle more abuse than the feed-through insulators. Leakage rates better than 10^{-14} cc/sec are guaranteed using this process which is known as the Durock 117 process. A bond is secured between the insulator and pin whereas in the Bendix insulator bonding was only accomplished at the surface of the insulator. The silico ceramic used (D117) has a resistivity of 2×10^{18} ohm cm, has very small strain currents, and is preconditioned to stand thermal shock.

d. Oscillator Circuit for Dynamic Capacitor

The circuit described in this section was developed along with Engineering Model "O" to indicate an approach to the design of the oscillator drive for the dynamic capacitor. It is not intended as a finished product, but serves as an actual configuration which might be considered in the final design of the drive. It was also intended to bring up any basic points which might be considered in any oscillator design. This section is written for the purpose of describing the operation of the circuit and pointing out certain principles of design which it is hoped will be helpful in the final design of the dynamic capacitor drive oscillator.

The principle upon which the drive oscillator functions can be shown with the aid of Fig. 3. As soon as the amplifier is energized, the saturating amplifier, which is essentially a free-running multivibrator running at a rate less than the resonant frequency of the diaphragm, will begin operation. This in turn drives the diaphragm, the vibrations of which are converted into voltage by the pickup coil mounted in the drive anvil. The voltage is applied to the linear amplifier in a positive feedback sense to sustain oscillation.

The detailed circuit diagram for the oscillator is shown on Dwg. No. B-11523 in the Appendix. To provide the proper conditions for starting and maintaining oscillations, it is important that the gain and phase shift of the amplifier be correct and relatively constant. To reduce the variation in phase shift with temperature, larger wire had to be used on the pickup coil. This improved the starting characteristics of the oscillator.

Once the oscillator is running, it is necessary for the a-c drive voltage and the polarizing voltage to remain constant to within approximately ± 10%, the exact value depending upon the characteristics of the dynamic capacitor. This is accomplished primarily by using a saturating amplifier at the output. Essentially a multivibrator, it locks into frequency by the feedback signal through the pickup coil. The output voltage delivered to the drive anvil and diaphragm is a function of the characteristics of the transformer and the switching characteristics of the 2N708's which supply the primary. Taps are provided on the secondary of the transformer for more flexibility in matching to dynamic capacitors of varying characteristics.

The sinusoidal voltage from the pickup coil appears at the input terminals of the oscillator. The signal is a-c coupled to a common base amplifier, thus providing a low-impedance input to give a good match with the pickup coil of the dynamic capacitor, and, at the same time, provide a high output impedance for the first stage. In this manner, a substantial voltage gain is achieved with operation stabilized by means of the 47 pf, 820 K parallel combination from the second stage collector to the first stage emitter. Thus, for a positive increasing input voltage, the 2N2511 transistor current decreases, making the base of the 2N2604 go more positive. This in turn also decreases the collector current through the second stage, making the feedback point more negative. An increasing negative voltage peak at the 2N2511 emitter tends to increase the collector current which is opposite to the signal in the first place. While negative feedback is achieved through the R - C combination, positive feedback is obtained through the 330 K resistor connected back to the base of the 2N2511. An increasing negative voltage at this point tends to decrease the collector current through the stage which is the same action initiated by the signal. Thus, the low frequencies are boosted by the 330 K feedback resistor, stabilized by the 820 K negative feedback resistor while the high frequencies are attenuated by the

47 pf capacitor. The R-C combination provides a break point toward 6 db per octave attenuation at about 26 KC.

The signal is a-c coupled to the third stage via the 0.001 mfd condenser to the 2N910 connected as a phase splitter to supply the drivers for the final stage flip-flop. The driver is essentially a free-running multivibrator whose operating frrquency is just below the 5 KC resonant frequency of the diaphragm. The outside pair of 2N708's drives the inside pair which couples to the capacitor through a transformer as shown in Dwg. B-11523. The 10 MH choke provides for efficient current switching in this power stage. The secondary circuit consists of a full-wave rectifier which provides the polarizing voltage in series with the 5 KC a-c drive voltage. The drive side of the dynamic capacitor is connected across the output with the pickup coil from the unit providing voltage for the input to the oscillator.

A $\pm$ 15 volt source is required and the power drawn is approximately 50 milliwatts. It is believed, however, that this power level could be brought down considerably when the exact characteristics of the capacitor are specified and thus the transformer can be especially designed for that purpose.

e. Results of PTM Production

After the Durock process was accepted as the assembly method on the structure of the dynamic capacitor, prototype units 8 and 9 were constructed. This was followed by the last phase of the contract, the production of 3 proof-test-model (PTM) units. Here an attempt was made to produce units of like characteristics which might serve as flight hardware.

The units were assembled and preliminary tests made after which they were delivered to JPL. The results of the tests are shown in Table II. Units 8 and 9 complete the prototype phase; units 10 - 12 constitute the PTM (proof-test-model) stage. C_{DR} refers to the rest capacity between the diaphragm and drive anvil. The variation between units is seen to be from 22.5 pf to 25.6 pf, or about 14%. C_{pu} refers to the rest capacity between the pickup anvil and the diaphragm and has a spread of 53.4 pf. to 61.5 pf., or about 14%. The coupling capacitor, which is built in to the unit has values ranging from 52.0 pf. to 54.6 pf., or about 5%.

Driving voltages have been selected to provide a conversion efficiency of 7% for each of the capacitors. This gives a comparison between the various units and should be useful in selecting a final value to use with a given capacitor. The 2 voltages are applied in series, the a-c source having a frequency the same as the resonant frequency of the diaphragm. The polarizing voltage is selected to minimize second-harmonic distortion. In general, it is recommended that an a-c drive voltage of 80 and a d-c polarizing voltage of 150 volts be used. The resonant frequency is very stable, as can be seen with reference to Table I. The variation between units is only 33 cps, or about 0.7%. The critical quantities which affect frequency are the thickness of the membrane and the gold plating, the effective area of vibration and the heat treatment applied to the diaphragm.

It has been mentioned that contact potential is the most difficult problem with the dynamic capacitor. By taking extreme care in the electroplating of the parts and in the assembly and the outgassing, it is possible to keep this potential within reasonable limits. However, the actual cause of contact potential continues to be somewhat of a mystery and does not appear to follow the simple theories of work function which have been outlined in the literature. It will be noted that considerable scatter exists in the data. These readings were taken about 48 hours after outgassing had been started. Therefore, it is quite possible that the readings would be different, hopefully smaller and closer together after two weeks of operation using temperature cycling.

The last column of Table II shows the magnitude of the pickup voltage measured for each capacitor. The spread of output voltages depends upon the uniformity which can be obtained in the leakage values present in each coil. The values obtained range from 12 to 26 millivolts rms. It is recommended that a small transformer be used to step up to a value sufficient for the oscillator circuit.

Further tests were carried on at JPL with the 5 units. The results indicated that conversion efficiency dropped to one-half its room temperature value at 90° C. Also, there was a frequency variation in the order of 50 cycles per second over the range. This is a new phenomena and is believed to be caused by uneven expansion of the clamping screw which holds the diaphragm in place and its supporting structure which is made from a different steel. If this is the difficulty, there should be no difficulty in correcting this fault, since it simply involves the use of the same material for the screw and the support.

V. CONCLUSIONS AND SUGGESTIONS FOR FUTURE EFFORT

1. It is very important to find out more about the mechanisms which produce what is called contact potential and learn ways of controlling not only its magnitudes, but the way it varies with time and temperature.
2. Any deviations from the specifications which are found in prototypes 8 and 9 and PTM's 10, 11, and 12, should be dealt with and

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corrected in future units.

3. Concentrate on improving the magnetic pickup coil or consider other transducers which might be used to pick up the oscillations of the dynamic capacitor and provide a suitable input for the oscillator.

4. Consider methods of mounting the dynamic capacitor for the purpose of stabilizing conversion efficiency and providing vibration isolation from the structure.

TABLE I. List of drawings as they appear in the Appendix

Dwg. No.	Title	Remarks
C-11387-1	Dynamic Capacitor--Center Supported Membrane	Main assembly drawing of the unit.
C-11528	Pickup Assembly	Complete upper portion of the unit.
C-11529	Driving Assembly	Complete lower portion of the unit.
B-11384-1	Shield	Outer case of unit
B-11375-1	Driving Housing	Holds drive anvil
B-11374-1	Pick-Up Housing	Holds pickup anvil.
B-11523	Capacitor Electrostatic Drive Oscillator	Circuit diagram
A-11530-2	Pin	Leads to drive anvil & pickup anvil
A-11534	Magnet	For pickup coil
A-11388-3	Washer # 3	Drive capacitance spacer
A-11388-2	Washer # 2	Drive capacitance spacer
A-11386-2	Driving Anvil	
A-11383	Membrane	
A-11535	Cover, Magnet	at bottom of pickup coil
A-11530-4	Pin	In magnetic circuit of pickup coil
A-11388-1	Washer # 1	Spacer for pickup housing
A-11536	Base, Mounting Magnet	In magnetic circuit
A-11376	Ring, Spacer	Between drive and pickup housings
A-11530-3	Pin	Lead to drive anvil
A-11525	Coil	Pickup
A-11533	Tube	For outgassing
A-11379	Coupling Anvil	For coupling capacitance

TABLE I, CONT.

Dwg. No.	TITLE	Remarks
A-11377	Pick-up Anvil	
A-11527	Pin & Anvil Assembly	See C-11528
A-11380-1	Central Pin	To pickup anvil
A-11526	Sleeve	Around pin A-11530-4

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TABLE II

DYNAMIC CAPACITOR TEST REPORT

MODEL DYX	SERIAL NO	CAPACITANCES C_{DR} pF	C_{PU} pF	C_c pV	DRIVING VOLTAGES FOR $\eta = 7\%$ AC V. RMS	DC V	RES FREQ. C/SEC	CONTACT POT AT 20°C MV	MAGN PU FOR $\eta = 7\%$ MV RMS
P	8	23.8	61.5	54.6	80	205	4902	+20	13
P	9	22.5	54.9	52.7	80	110	4884	−100	12
PTM	10	22.9	53.4	52.0	80	130	4902	+8	26
PTM	11	25.6	59.6	52.8	80	90	4880	−25	23
PTM	12	23.0	57.6	52.0	80	120	4918	+65	20

CASE MAT. 304 SS
INSULATORS PSC DUROCK
MACHINING : J. NUNN
MEMBRANES : ENGELHARD .010 NI. SP. C
GOLDING : INLAND EL 3-64
ASSEMBLY : 3-17-1964
SEALING : 3-20-1964
INS RES . $2 \cdot 10^{14}\,\Omega$ (PU·CAD − GND)
-"- -"- $1 \cdot 10^{13}\,\Omega$ (C.C − GND)
ISOLATION POT BETWEEN DR AND INPUT (FOR 7% EFF) : .6 mV

RABruns
C Epr

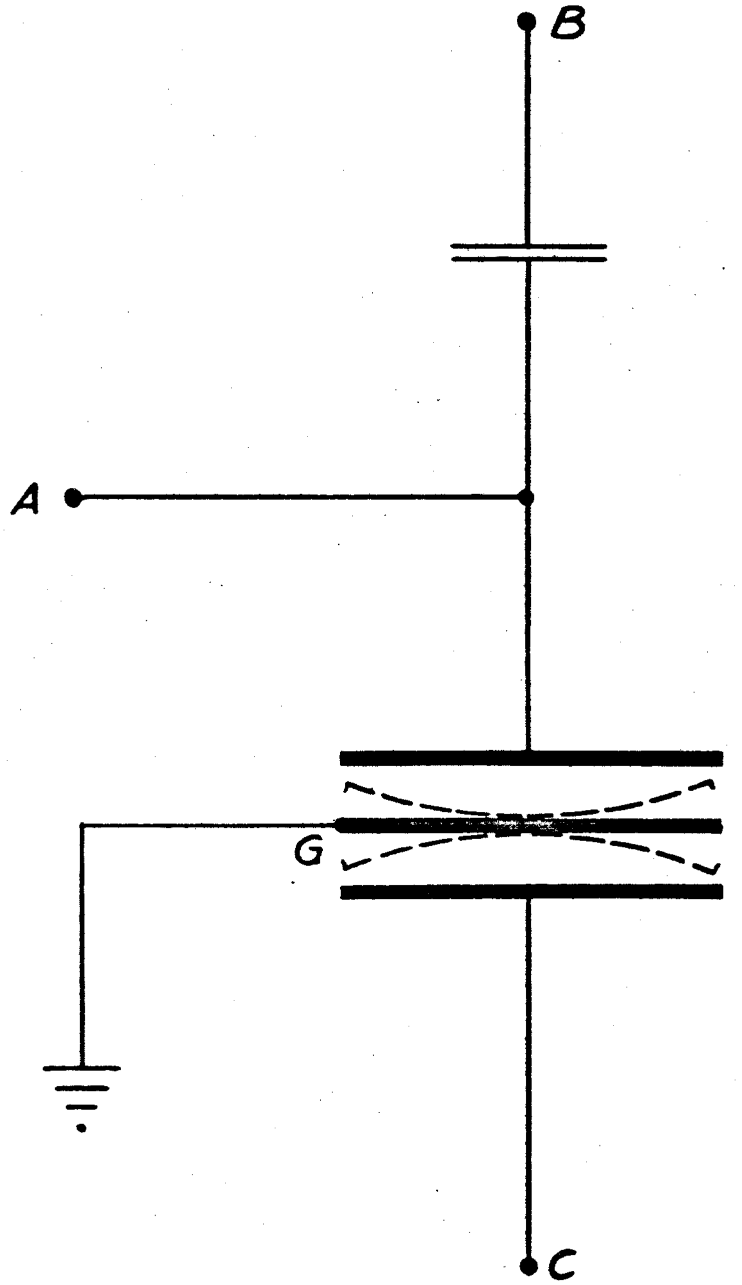


FIG 1. ELECTRICAL CIRCUIT OF DYNAMIC CAPACITOR

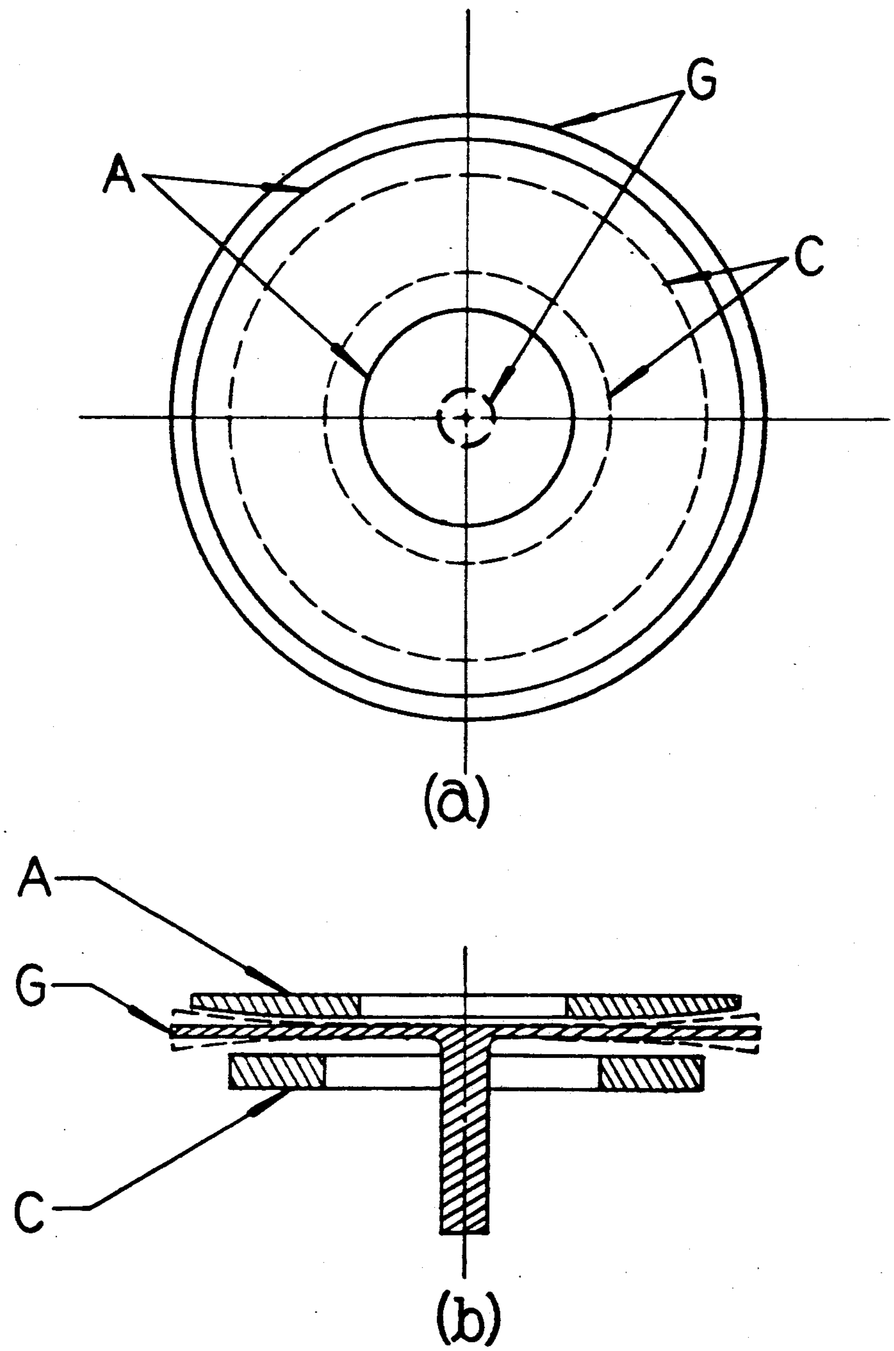


FIG. 2. BASIC CONSTRUCTION OF CENTER SUPPORTED DRIVE SYSTEM

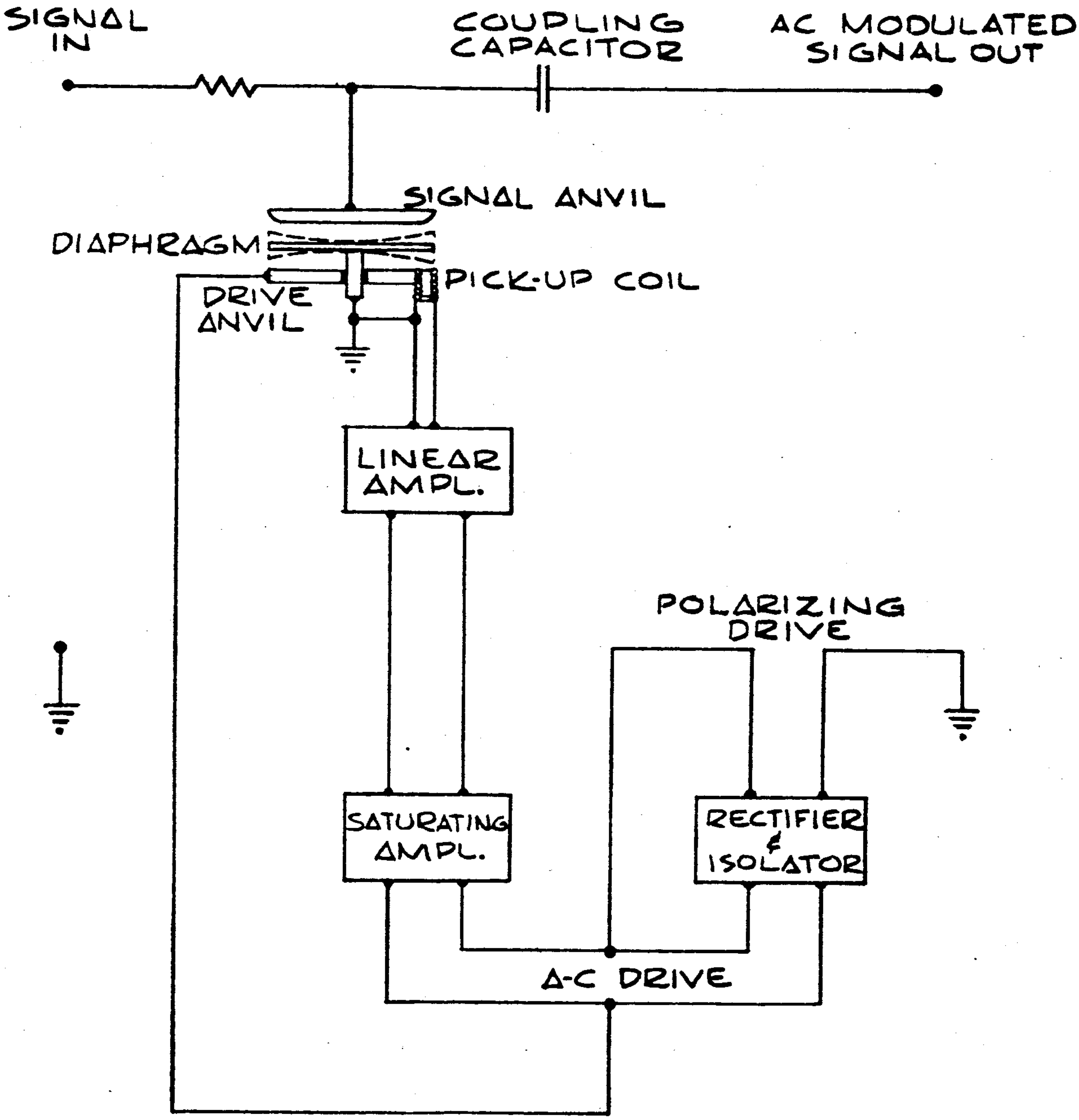
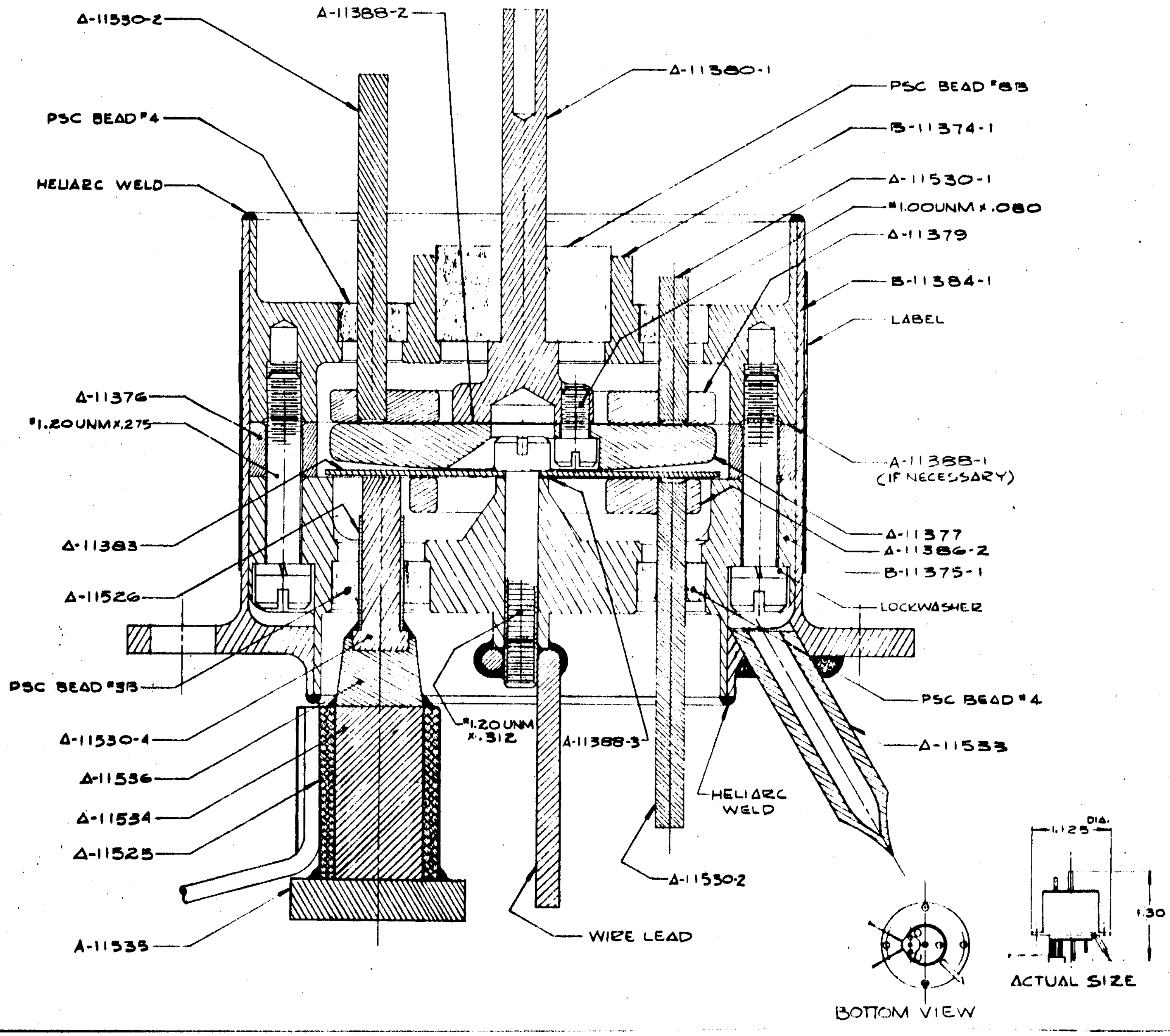


FIG. 3. BLOCK DIAGRAM OF OSCILLATOR

APPENDIX



C-11387-1

REVISIONS				
CHG	DESCRIPTION	DATE	BY	CHK

TYPE	
NEXT ASS'Y	

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX. .010 MIN
1.000	± .005	3. THREADS CLASS 2
ANG	± 1/2°	4. FILLET RADII .010 MAX
		5. SURFACES 63 MICRO INCH R.M.S. MAX

MAT'L
FINISH

DATE 2-7-64
DWN KAT
CHK C.T.N.
APP J.T.C.
DATE 2/7/64

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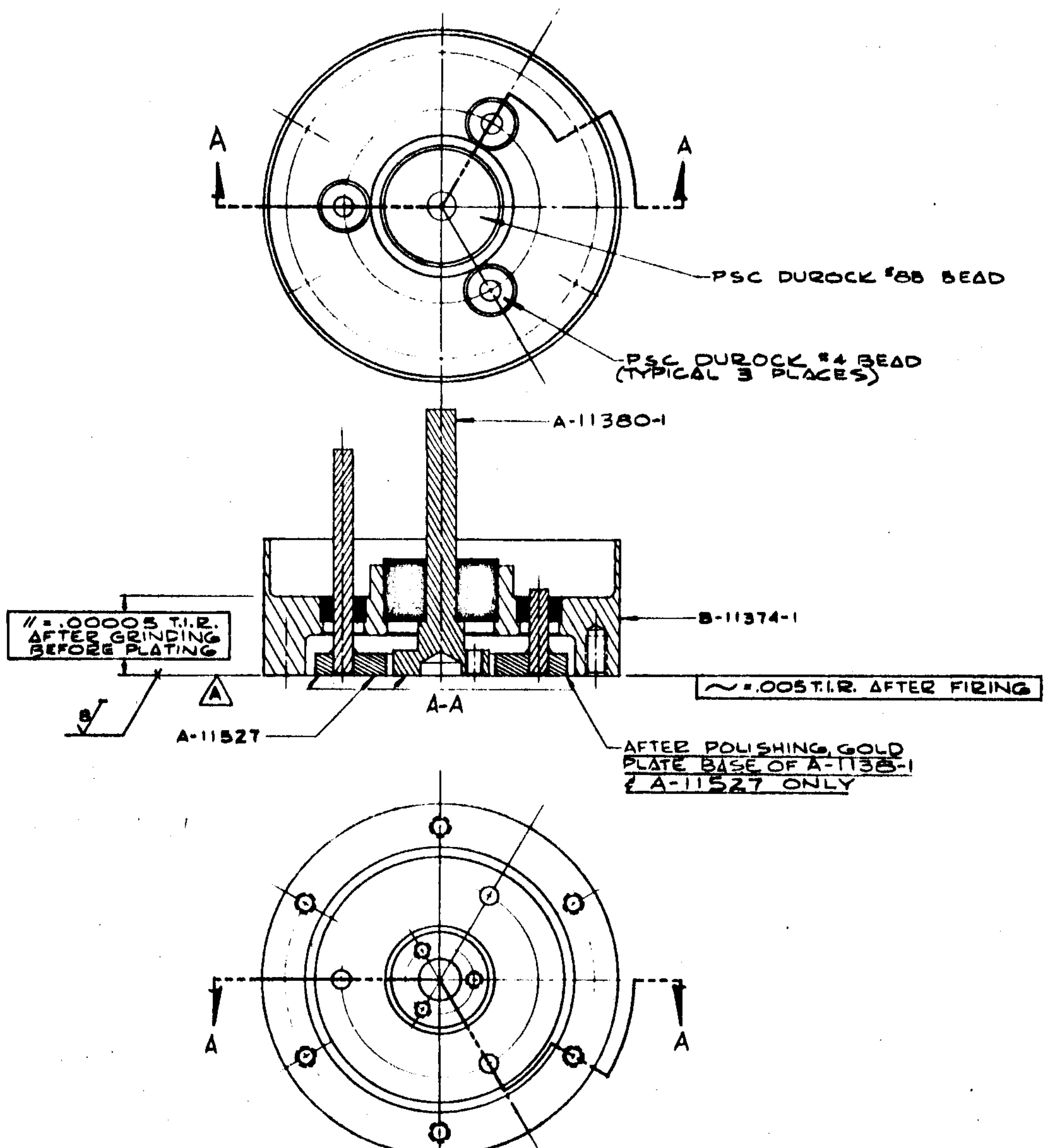
DYNAMIC CAPACITOR CENTER SUPP'T'D MEMB'R

SCALE 10x1 | C-11387-1 | CHG



NOTES:
1. ALL BEADS USE D-117 P.S.C. DUROCK.
2. INSULATION RESISTANCE MEASURED BETWEEN A-11379 & B-11374-1 AT 50V SHOULD EXCEED 2×10^{13} Ω.
5. HELIUM LEAKAGE RATE BETTER THAN 1×10^{-10} CC/SEC.
4. INSULATION RESISTANCE MEASURED BETWEEN A-11380-1 & B-11374-1 AT 50V SHOULD EXCEED 2×10^{14} Ω.
5. THE POSITION OF THE 3 TAPPED HOLES ON PART A-11380-1 ARE NOT CRITICAL DURING ASSEMBLY.

REVISIONS				
CHG	DESCRIPTION	DATE	BY	CHK

C-11528 | CHG

TYPE	
NEXT ASS'Y	

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX. .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG	± 1/2	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L

FINISH

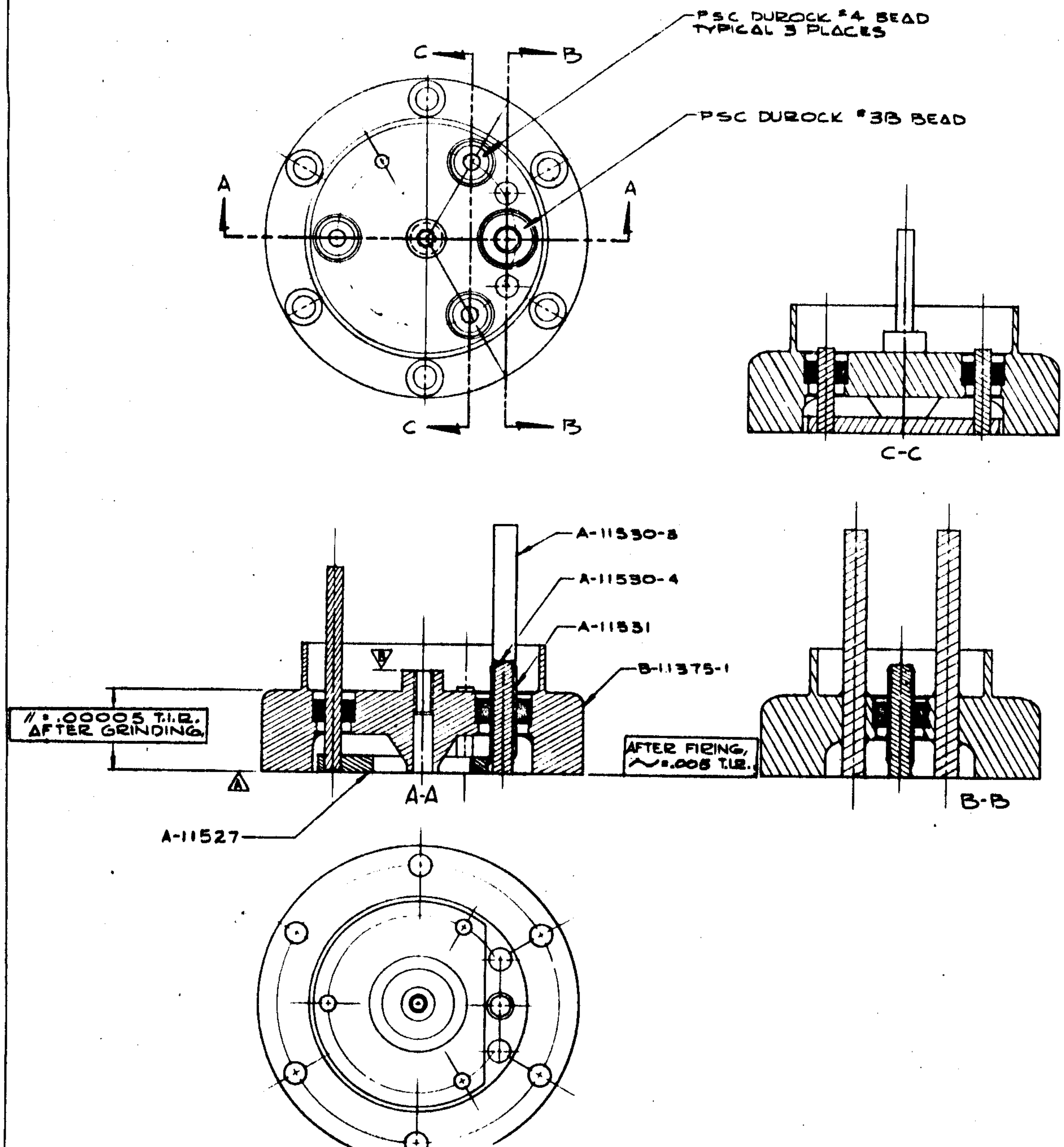
DATE 2-10-64
DWN KAT
CHK
APP
DATE 2-12-64

DO NOT COPY, DISPLAY, OR USE DRAWING WITHOUT AUTHORIZATION — DO NOT SCALE DRAWING

KINELOGIC CORPORATION

PICK-UP ASSEMBLY

SCALE 5:1 | C-11528 | CHG



5. SOFT SOLDER 1 PIN (A-11530-4) INTO PLACE AFTER FIRING.
4. SOFT SOLDER 2 PINS (A-11530-8) INTO PLACE AFTER FIRING.
3. HELIUM LEAKAGE RATE BETTER THAN 1×10^{-10} CC/SEC.
2. INSULATION RESISTANCE MEASURED BETWEEN A-11386-2 & B-11375-1 AT 50V SHOULD EXCEED 2×10^{10} Ω.
NOTES: 1. ALL BEADS USE D-117 P.S.C. DUROCK.

REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK

C-11529 | CHG

TYPE	
NEXT ASS'Y	

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX. .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG	± 1/2°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L	DATE 2-6-64
	DWN KAT
FINISH	CHK
	APP.
	DATE 2-10-64

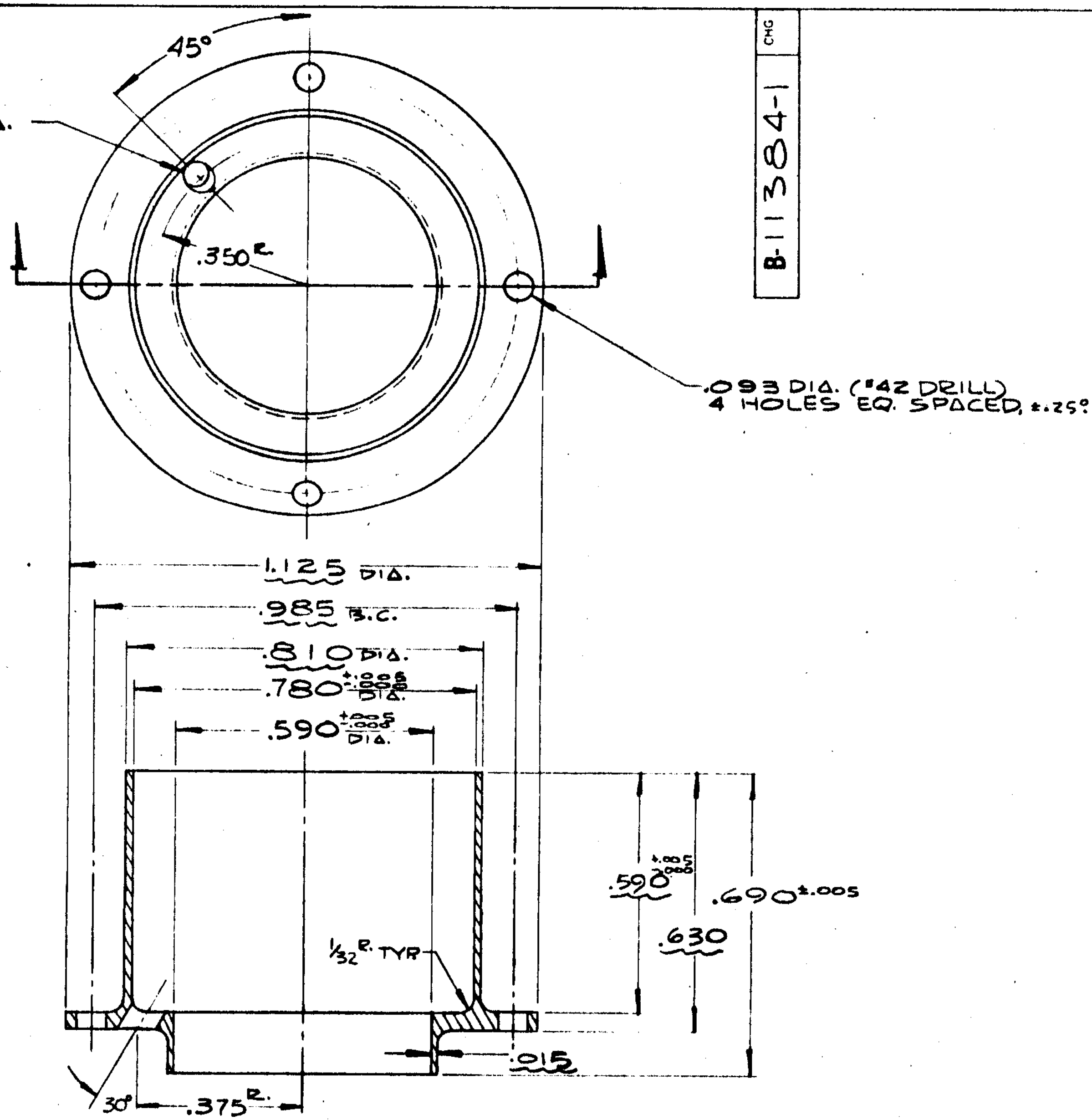
DO NOT COPY, DISPLAY, OR USE DRAWING WITHOUT AUTHORIZATION — DO NOT SCALE DRAWING

KINELOGIC CORPORATION

DRIVING ASSEMBLY

SCALE 5:1 | C-11529 | CHG.

B-113B4-1 CHG



REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK.

TYPE

NEXT ASS'Y

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX. .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG	± 1/2	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 304 ST. ST'L

FINISH

DATE 2·10·64
DWN. KAT
CHK. [illegible]
APP [illegible]
DATE 2-1?-64

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KINELOGIC CORPORATION

SHIELD

SCALE 4·1

B-113B4-1 CHG.

2

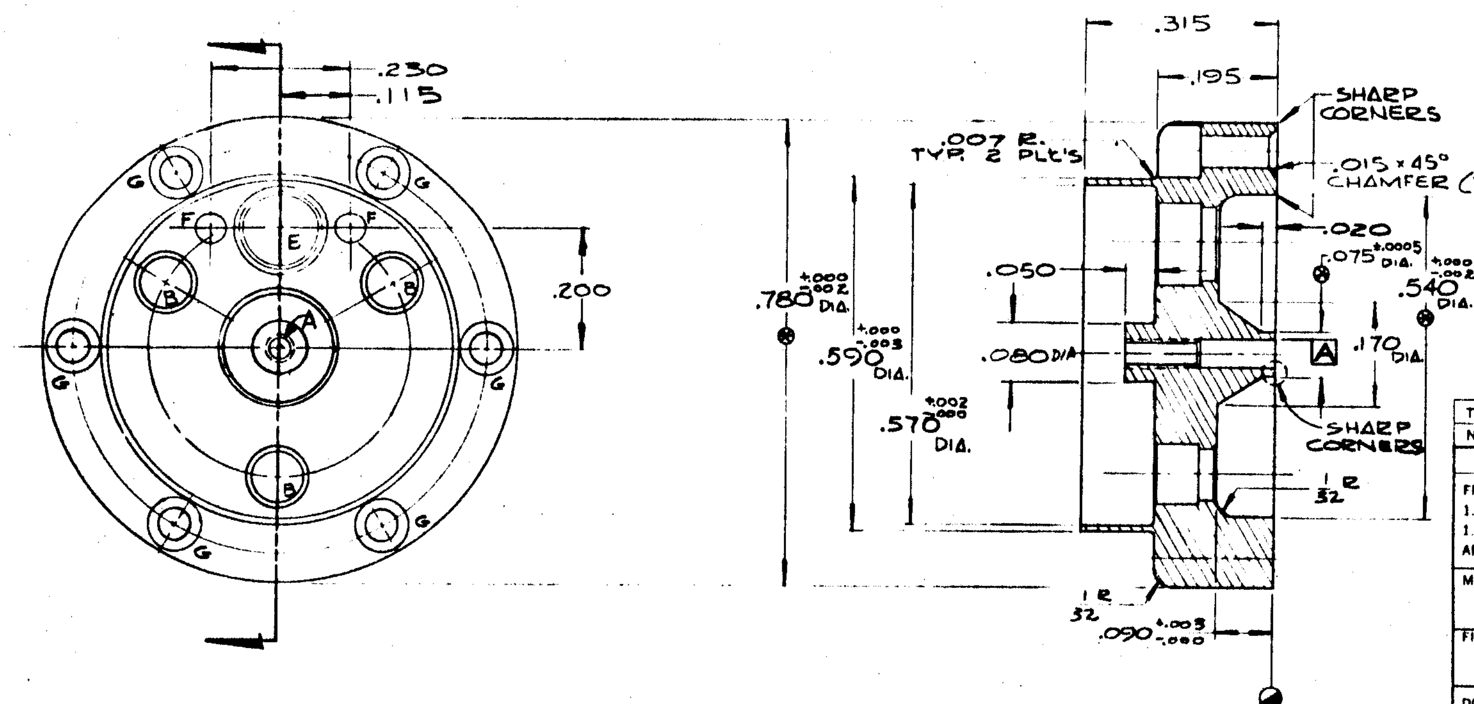
HOLE TABULATION

SYM	QTY	OPERATION
A	1	.0400 (#60) DIA. THRU. C'BORE (FARSIDE) .0492 ±.0005 (1.25MM) x .165 DP.; TAP (NEARSIDE) 120 UNM.
B	3	.086 $^{+.002}_{-.000}$ (#44) DIA. THRU. C'BORE (FLAT BOTTOM) .0995 $^{+.002}_{-.000}$ (#39) DIA. x .075 DP. C'SINK BOTH SIDES 110° x .004 ±.001 DP. HOLES EQ. SP. ±.25° ON .430 $^{+.002}_{-.000}$ B.C.
E	1	.125 $^{+.002}_{-.000}$ (1/8) DIA. THRU. C'BORE (FLAT BOTTOM) .1405 $^{+.002}_{-.000}$ (#28) DIA. x .075 DP. C'SINK BOTH SIDES 110° x .004 ±.001 DP.
F	2	.052 $^{+.002}_{-.000}$ (#55) DIA. THRU.
G	6	.052 (#55) DIA. THRU. C'BORE NEARSIDE .089 (#43) DIA. x .070 DP. HOLES EQ. SPACED ±.25° ON .680 ±.001 B.C.

B-11375-1 CHG A

REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK.



TYPE				
NEXT ASS'Y				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX. .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± 1/2°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 304 ST. ST'L	DATE 1-29-64
	DWN. K.A.T.
FINISH	CHK. [illegible]
	APP. [illegible]
	DATE 2-6-64

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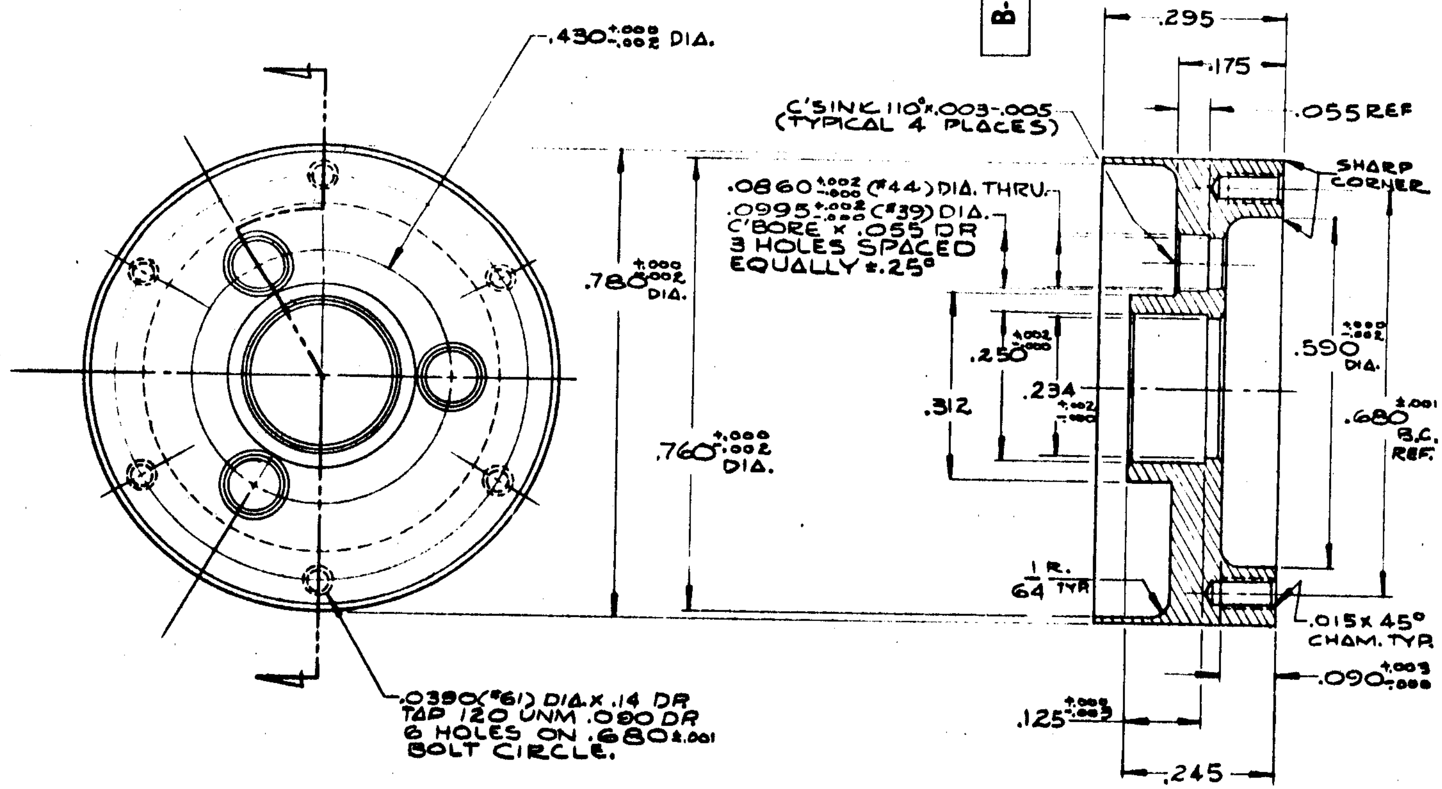
KINELOGIC CORPORATION

DRIVING HOUSING

SCALE		CHG.
5:1	B-11375-1	A

NOTES:
1. DIA'S MARKED ⊕ TO BE CONCENTRIC TO $\boxed{A}$ WITHIN .0005 T.I.R.
2. SURFACE MARKED ● TO BE PERPENDICULAR TO $\boxed{A}$ WITHIN .1°

36



REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK.

TYPE				
NEXT ASS'Y				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± 1/2°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 304 ST. STEEL	DATE 1-28-64
	DWN. KAT
FINISH	CHK. [illegible]
	APP. [illegible]
	DATE 2-6-64

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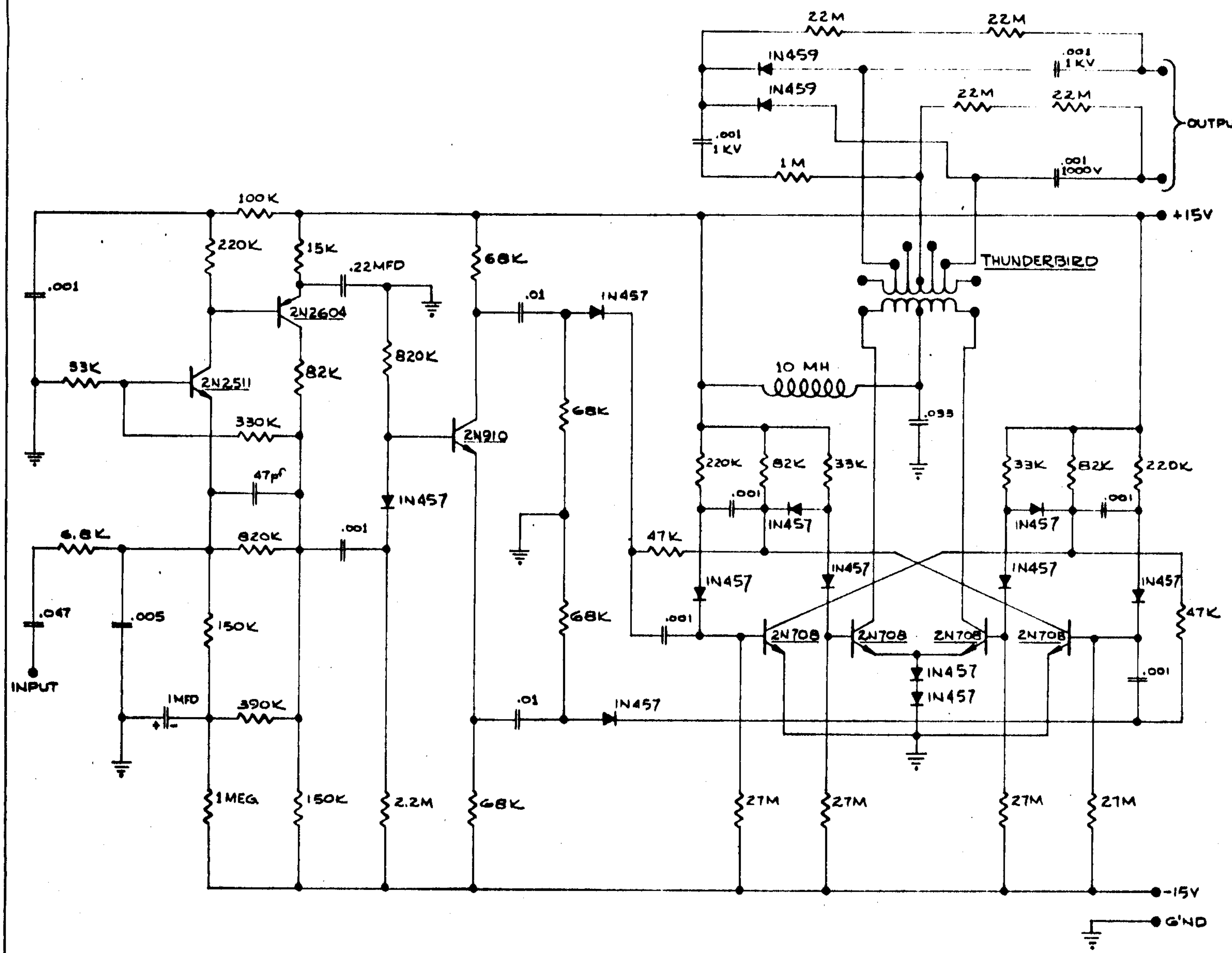
KINELOGIC CORPORATION

PICK-UP HOUSING

SCALE		CHG.
5:1	B-11374-1	



REVISIONS				
CHG	DESCRIPTION	DATE	BY	CHK.

TYPE	
NEXT ASS'Y	

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± 1/2°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. —
FINISH —

DATE 3-30-64
DWN. KAT
CHK.
APP. RAB
DATE 4-14-64

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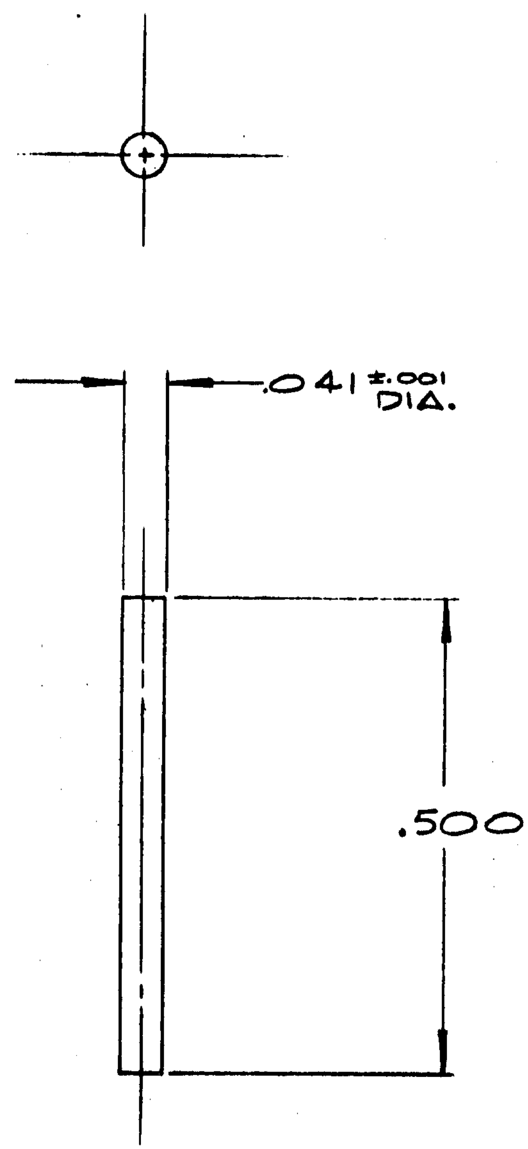
KINELOGIC CORPORATION

CAPACITOR ELECTROSTATIC DRIVE OSCILLATOR

SCALE —

B- 11523

CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	±1/64
1.00	±.010
1.000	±.005
ANG.	±½°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. INCONEL X

FINISH

DATE 1·29·64
DWN. KAT
CHK. [illegible]
APP. RB
DATE 2-10-64

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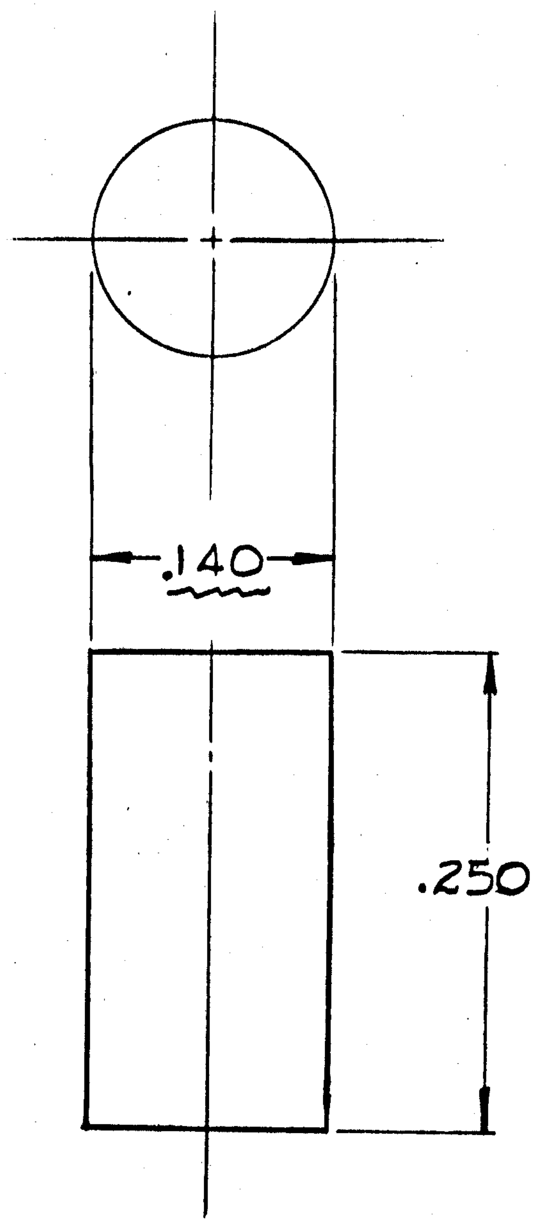
KINELOGIC CORPORATION

PIN

SCALE 5·1 | A-11530-2 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± ½°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. ALNICO 5

FINISH

DATE 2·14·64
DWN. KAT
CHK. [illegible]
APP.
DATE

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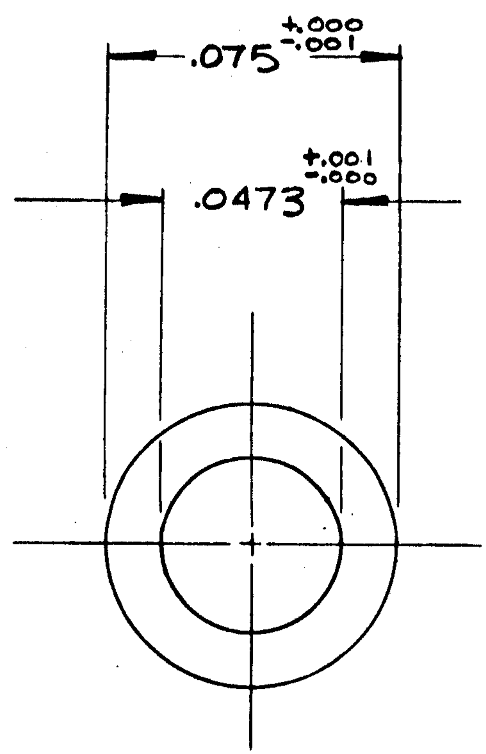
KINELOGIC CORPORATION

MAGNET

SCALE 10·1 | A-11534 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK.

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± 1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 17.4 PH ST. ST'L .00075 THICK

FINISH

DATE 4·1·64
DWN. KAT
CHK. C Rry
APP. RABruns
DATE 2-6-64

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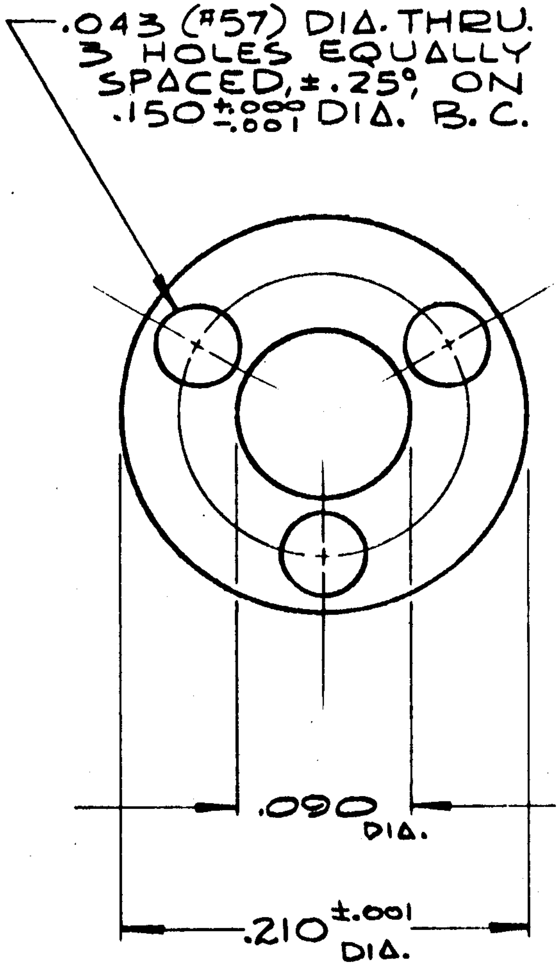
KINELOGIC CORPORATION

WASHER #3

SCALE 20·1

A-11388-3

CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK.

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± 1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 17.4 PH ST. ST'L. .00075 THICK

FINISH

DATE 4-1-64
DWN. KAT
CHK. [illegible]
APP. R.A.Bruns
DATE 2-6-64

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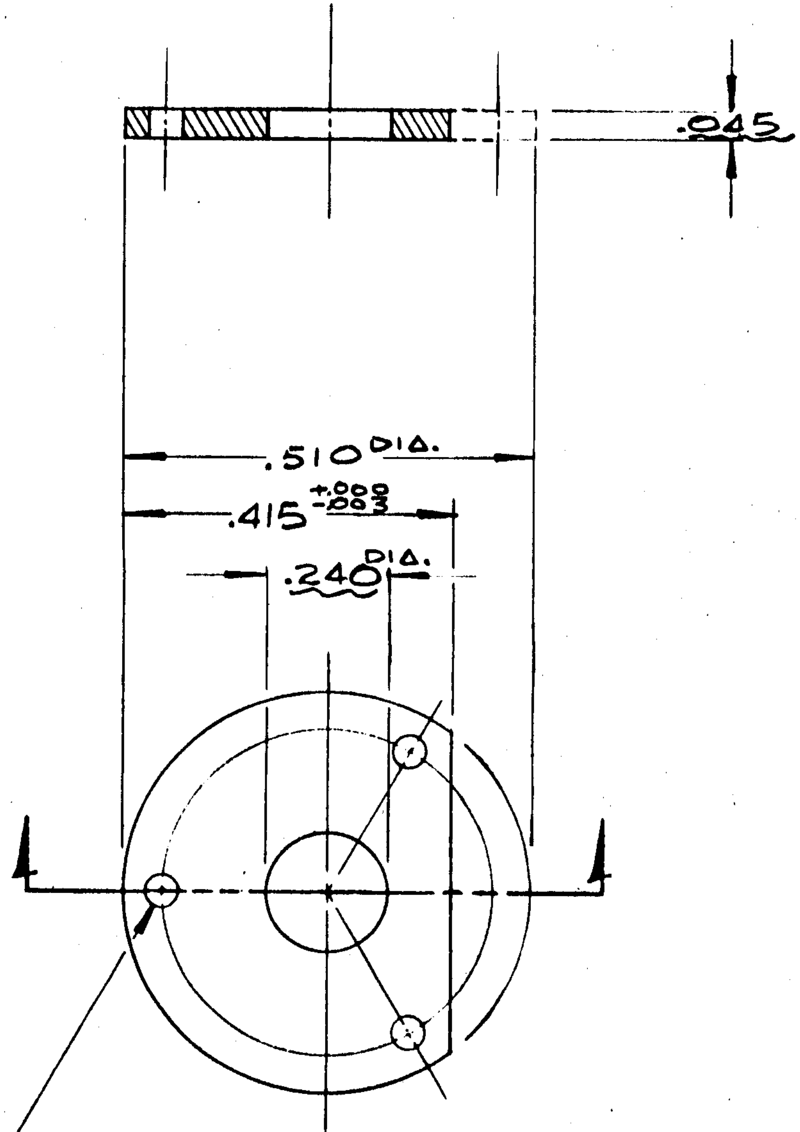
KINELOGIC CORPORATION

WASHER #2

SCALE 10:1 | A-11388-2 | CHG.



NOTES: 1. ALL EDGES 1/64 R.

REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	±1/64
1.00	±.010
1.000	±.005
ANG.	±1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX. .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 304 ST. ST'L

FINISH

DATE 1·29·64
DWN. KAT
CHK. [illegible]
APP. [illegible]
DATE 2-6-64

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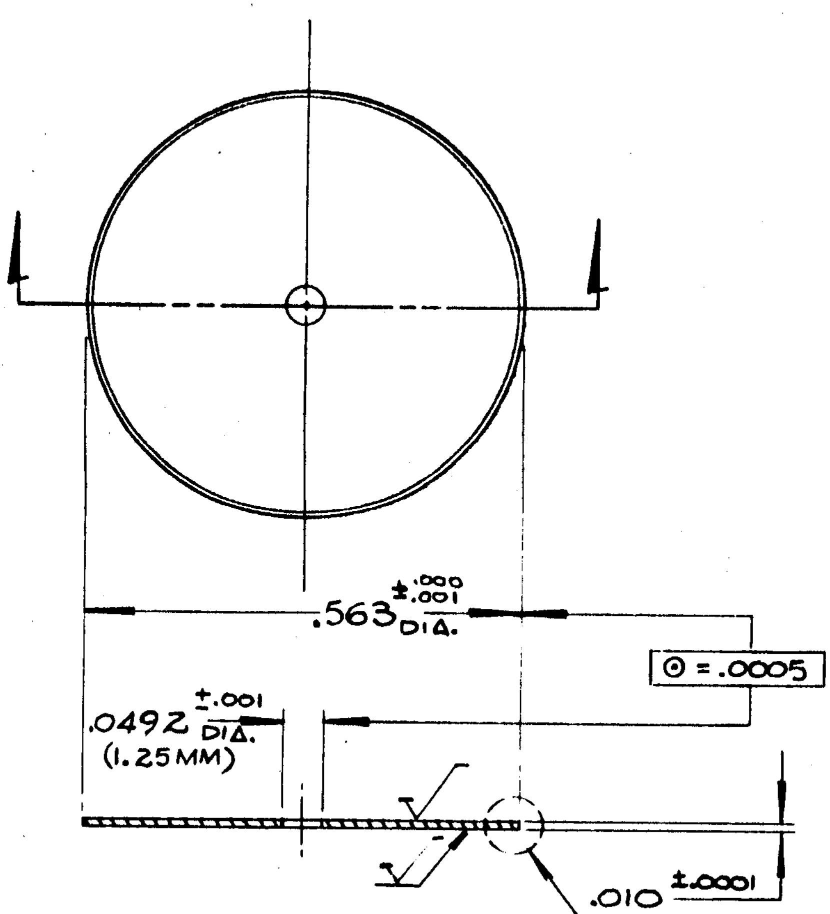
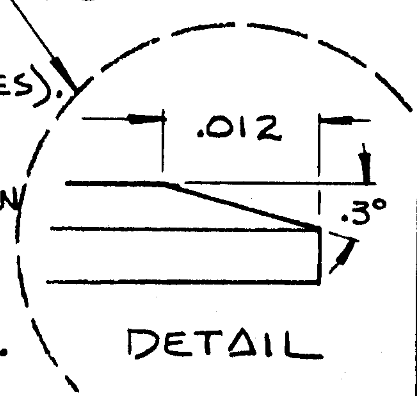
KINELOGIC CORPORATION

DRIVING ANVIL

SCALE 4·1 | A-11386-2 | CHG.





DETAIL

NOTES:

1. PUNCH 5/8 DIA. DISC & DEBURR.
2. PRESS MEMBRANE TOGETHER BETWEEN 2 FLAT ST. ST'L SURFACES & HEAT TREAT 5 HOURS AT 1100°F IN ARGON ATMOSPHERE.
3. MACHINE TO SIZE PER DWG.
4. LAP TO 8 MICRO-INCH FINISH (BOTH SIDES).
5. GOLD PLATE.

REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	±1/64
1.00	±.010
1.000	±.005
ANG.	±1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. NI. SP. C. 50% C.R. HEAT TREATED

FINISH

DATE 1·24·64
DWN. KAT
CHK. Clar
APP. RABrunner
DATE 2-6-64

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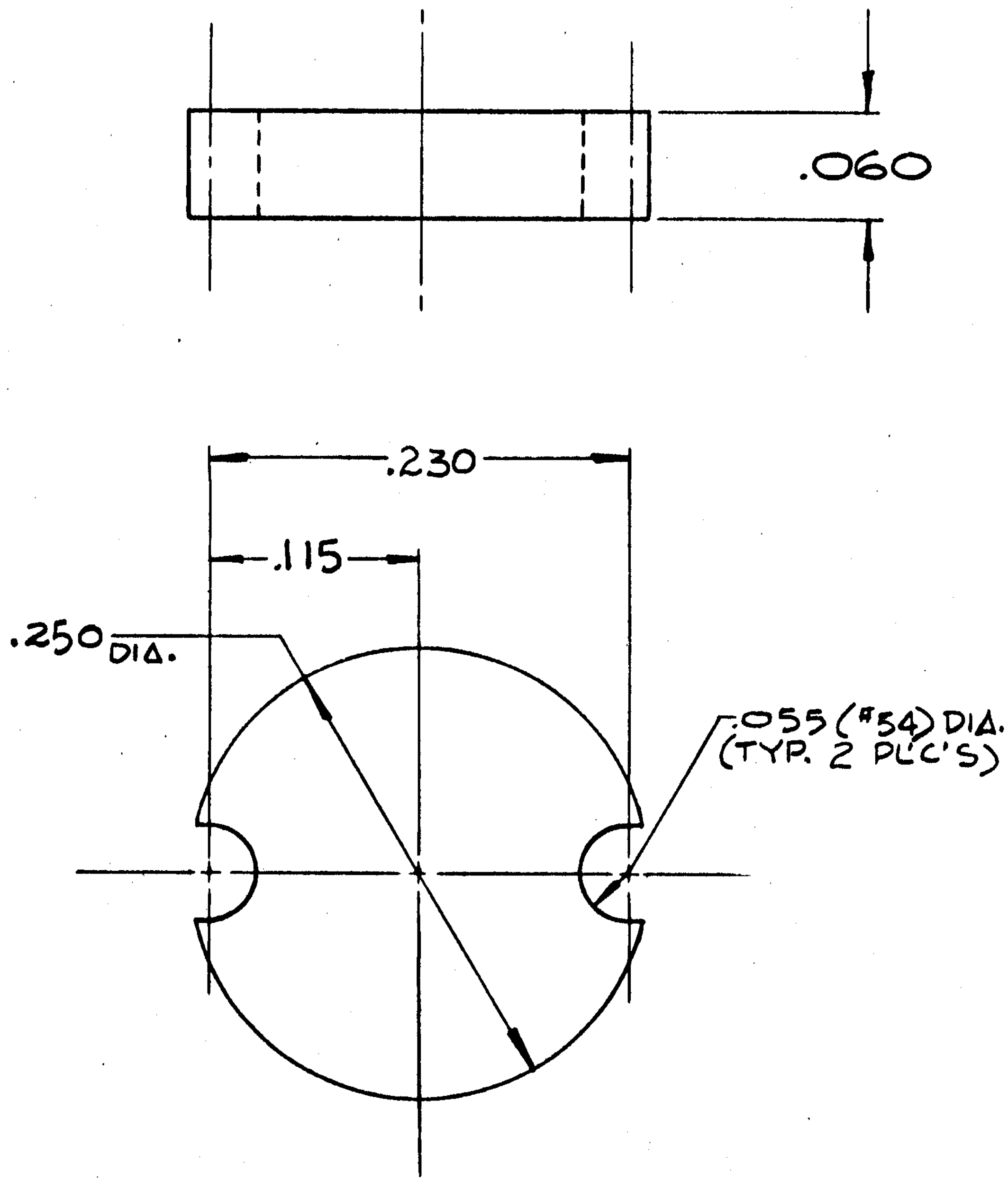
KINELOGIC CORPORATION

MEMBRANE

SCALE 4-1 | A-11383 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± 1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 4750 ST. ST'L	DATE 2-17-64
	DWN. KAT
FINISH	CHK. C Ling
	APP. RABrunt
	DATE 2-6-64

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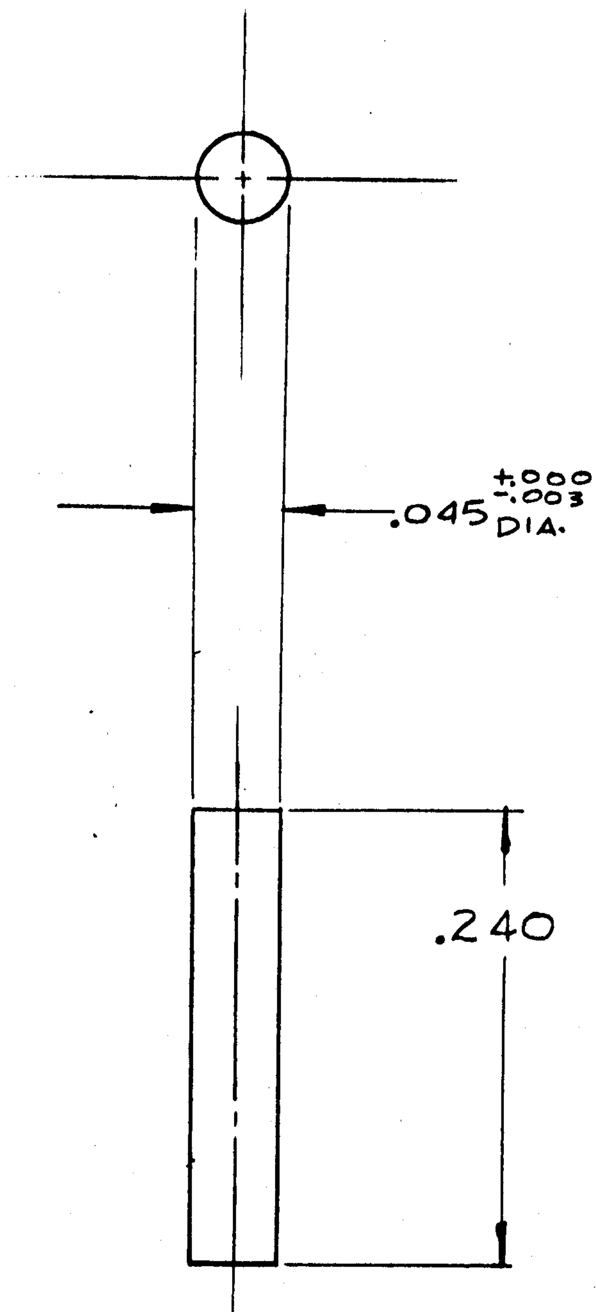
WITHOUT AUTHORIZATION — DO NOT SCALE DRAWING

KINELOGIC CORPORATION

COVER, MAGNET

SCALE		CHG.
10:1	A-11535	



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	±1/64
1.00	±.010
1.000	±.005
ANG.	±½°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 4750 ST. ST'L

FINISH

DATE 2·13·64
DWN. KAT
CHK. C. [illegible]
APP. R.A.Brun[illegible]
DATE 2-6-64

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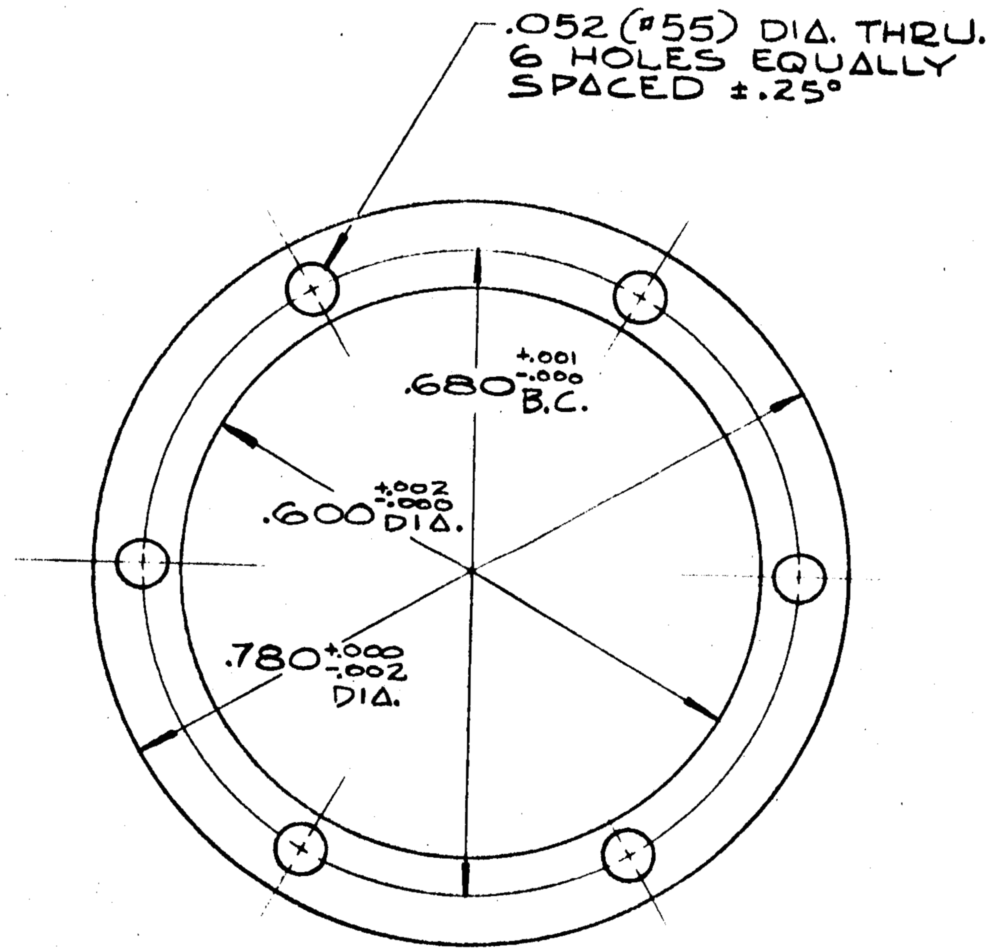
KINELOGIC CORPORATION

PIN

SCALE 10·1 | A-11530-4 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK.

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± 1/2	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 17.4 PH ST. ST'L .00075 THICK

FINISH

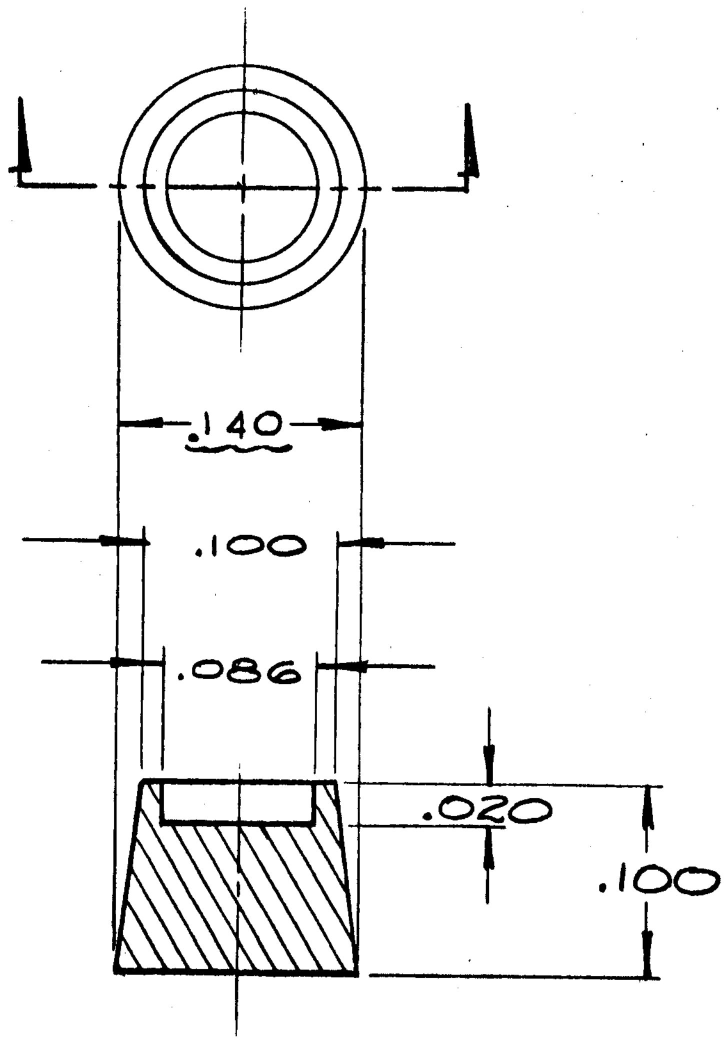
DATE 4-1-64
DWN. KAT
CHK. [illegible]
APP. RRBruns
DATE 2-6-64

DO NOT COPY, DISPLAY, OR USE DRAWING WITHOUT AUTHORIZATION — DO NOT SCALE DRAWING

KINELOGIC CORPORATION

WASHER #1

SCALE 5:1 | A-11388-1 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± ½°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 4750 ST. ST'L

FINISH

DATE 2-14-64
DWN. KAT
CHK. Carl
APP. RABrown
DATE 2-6-64

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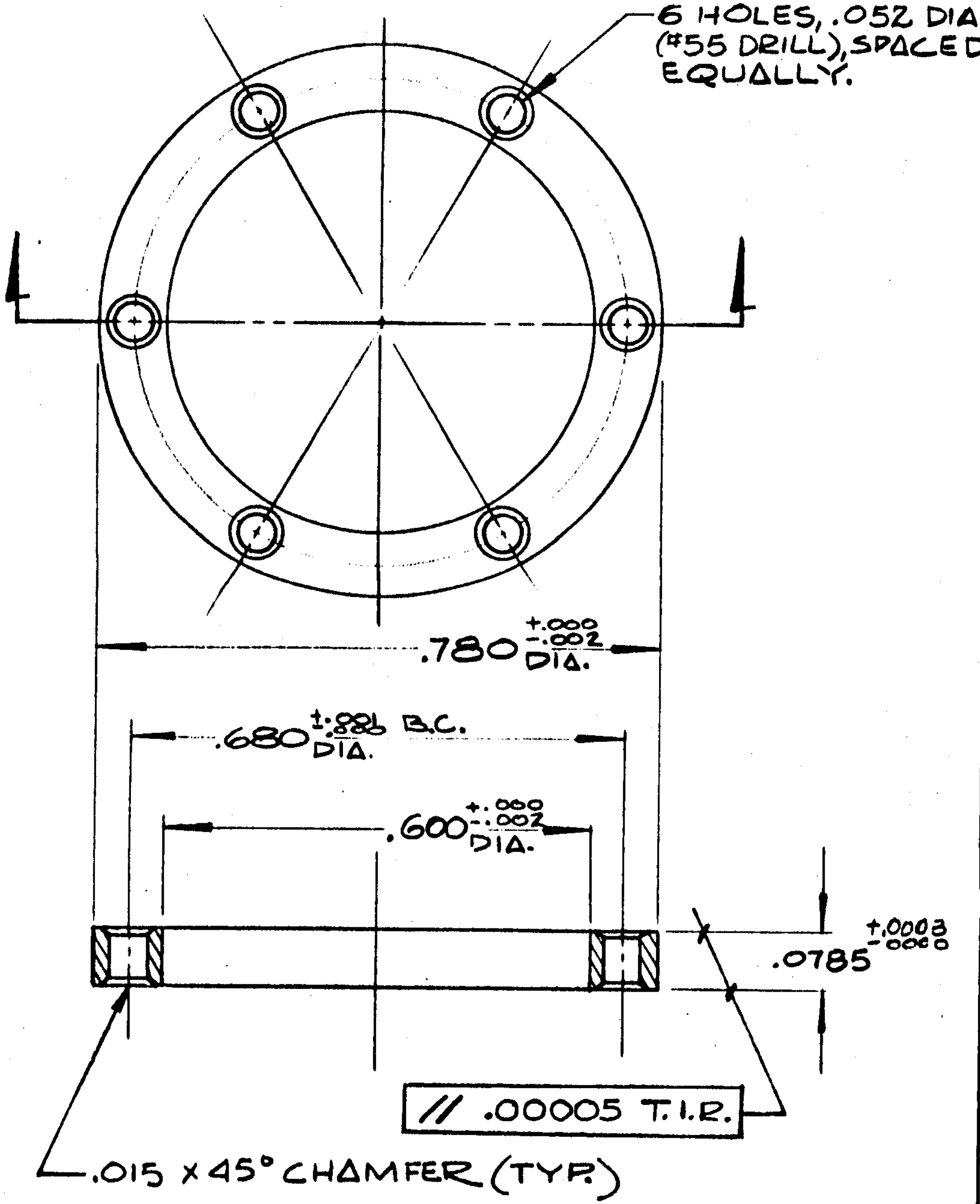
KINELOGIC CORPORATION

BASE, MOUNTING
MAGNET

SCALE 10:1 | A-11536 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± 1/2°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 304 ST. STEEL	DATE 1·24·64
	DWN. KAT
FINISH	CHK. Cl...
	APP. ...
	DATE 2-6-64

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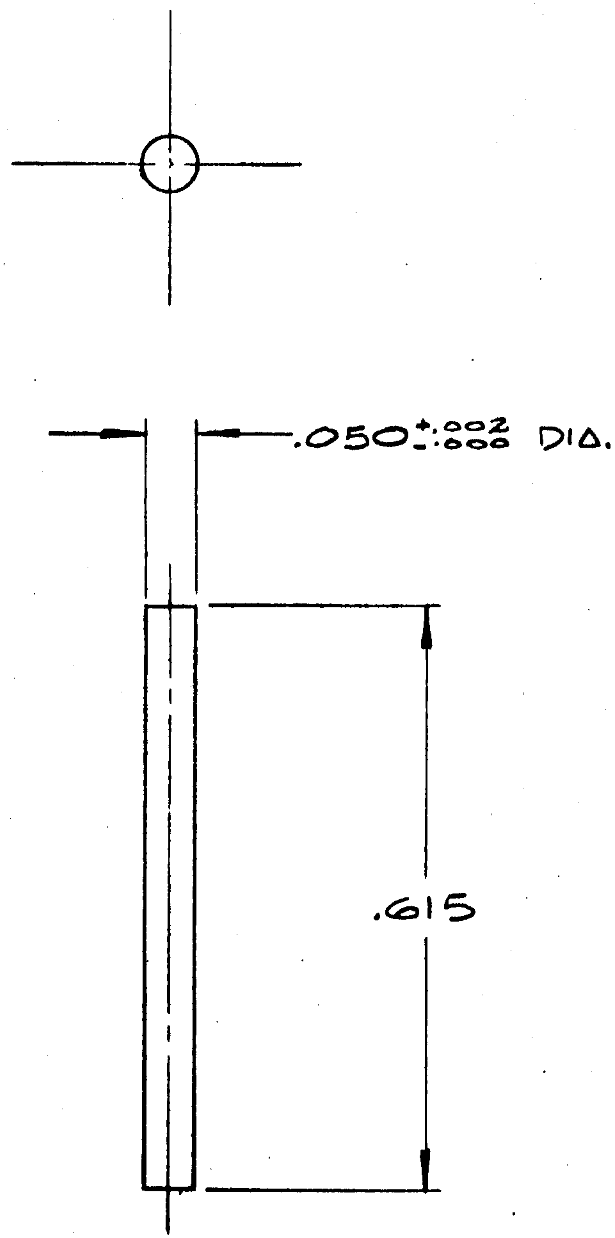
KINELOGIC CORPORATION

RING, SPACER

SCALE		CHG.
4·1	A-11376	



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± 1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 4750 ST. ST'L

FINISH

DATE 1·31·64
DWN. KΔT
CHK. [illegible]
APP. [illegible]
DATE 2-13-64

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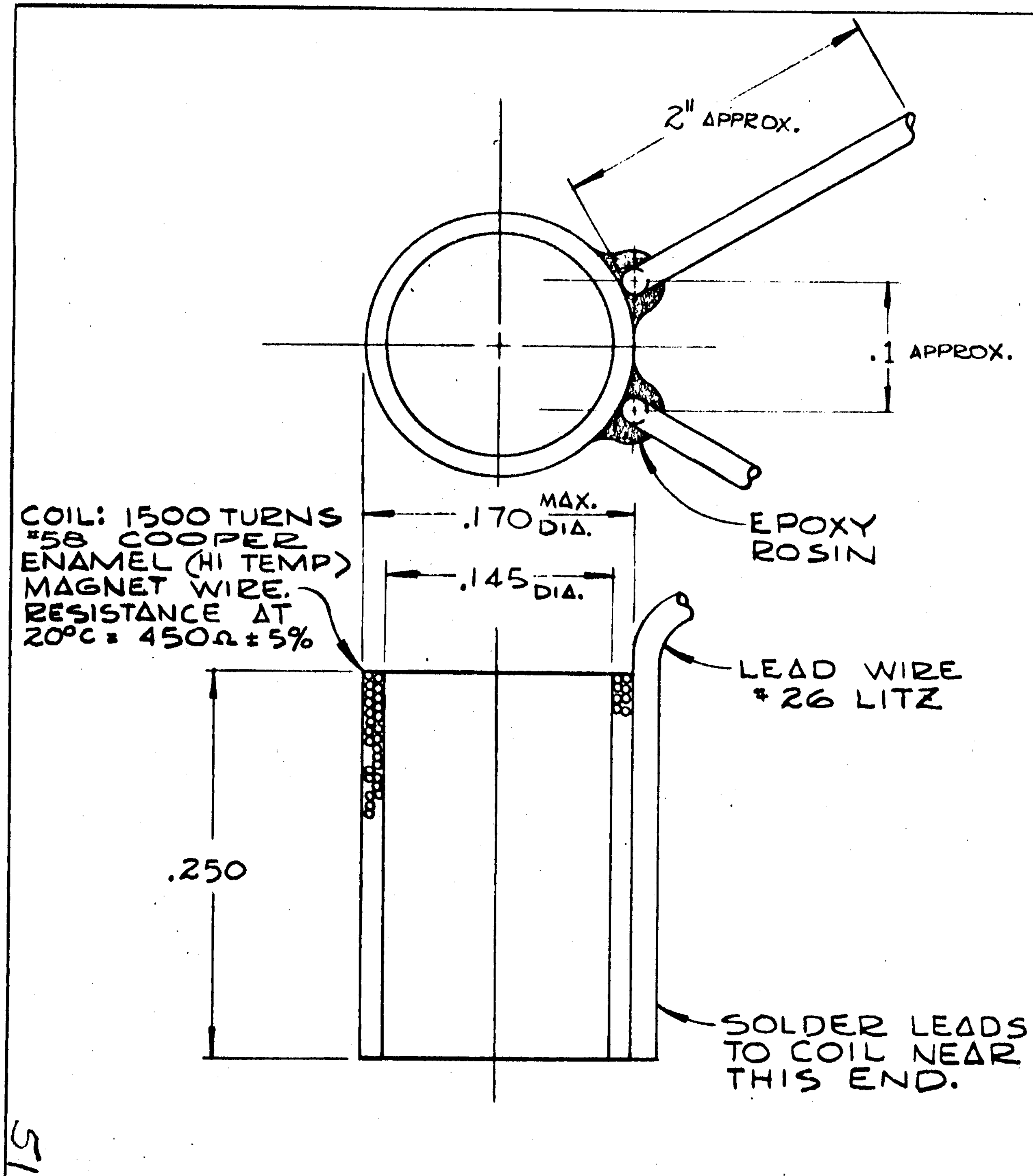
WITHOUT AUTHORIZATION — DO NOT SCALE DRAWING

KINELOGIC CORPORATION

PIN

SCALE 5·1 | A-11530-3 | CHG.

50



REVISIONS

CHG	DESCRIPTION	DATE	BY	CHK.

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± 1/2°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. AS NOTED	DATE 4.1.64
	DWN. KAT
FINISH COIL DIPPED IN EPOXY ECOCOAT #3561	CHK. [illegible]
	APP. [illegible]
	DATE 2-6-64

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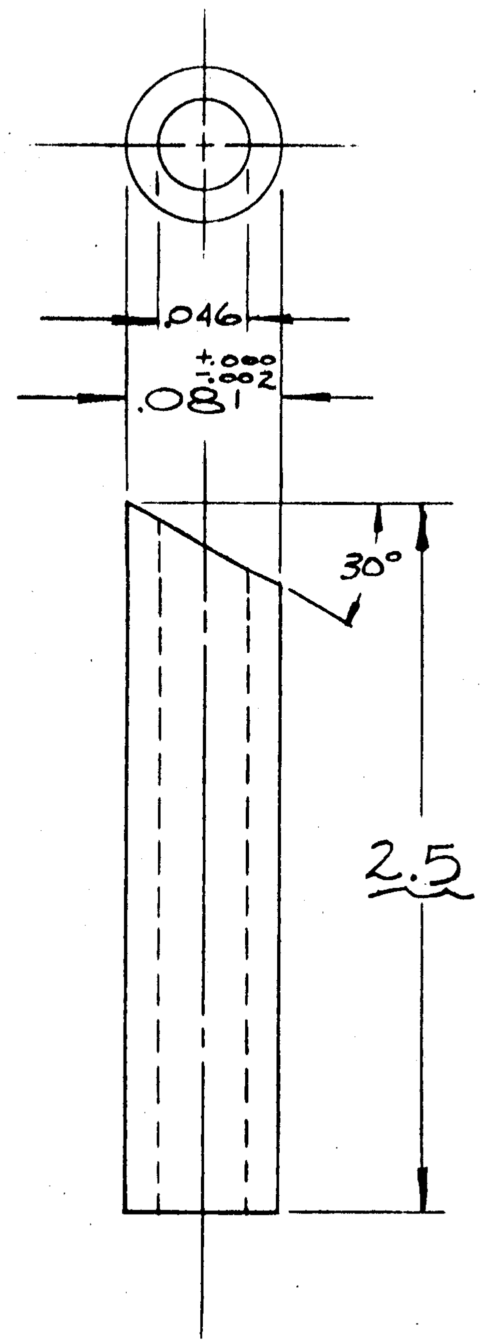
KINELOGIC CORPORATION

COIL

SCALE		CHG.
10:1	A-11525	



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± 1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. COPPER

FINISH

DATE 2-14-64
DWN. KAT
CHK.
APP. RAK
DATE 2-6-64

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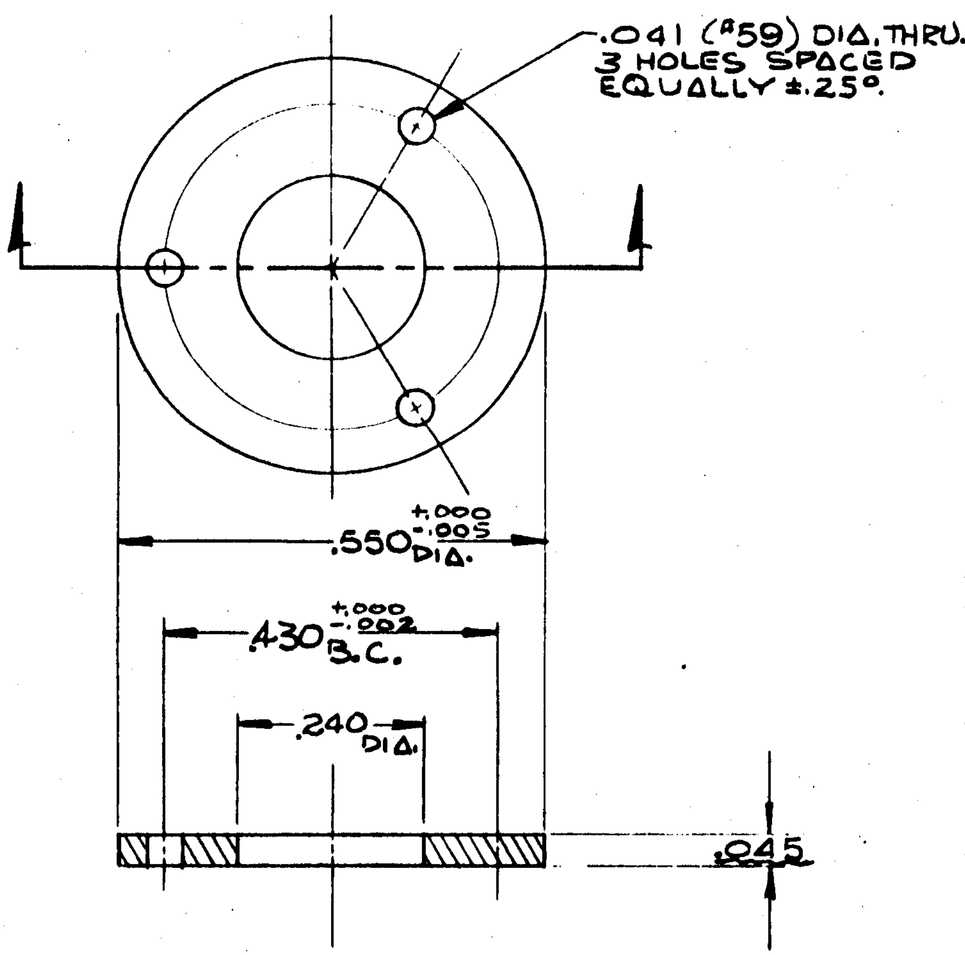
KINELOGIC CORPORATION

TUBE

SCALE 10:1 | A-11533 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± 1/2

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 304 ST. ST'L

FINISH

DATE 1·27·64
DWN. KAT
CHK.
APP.
DATE 2-6-64

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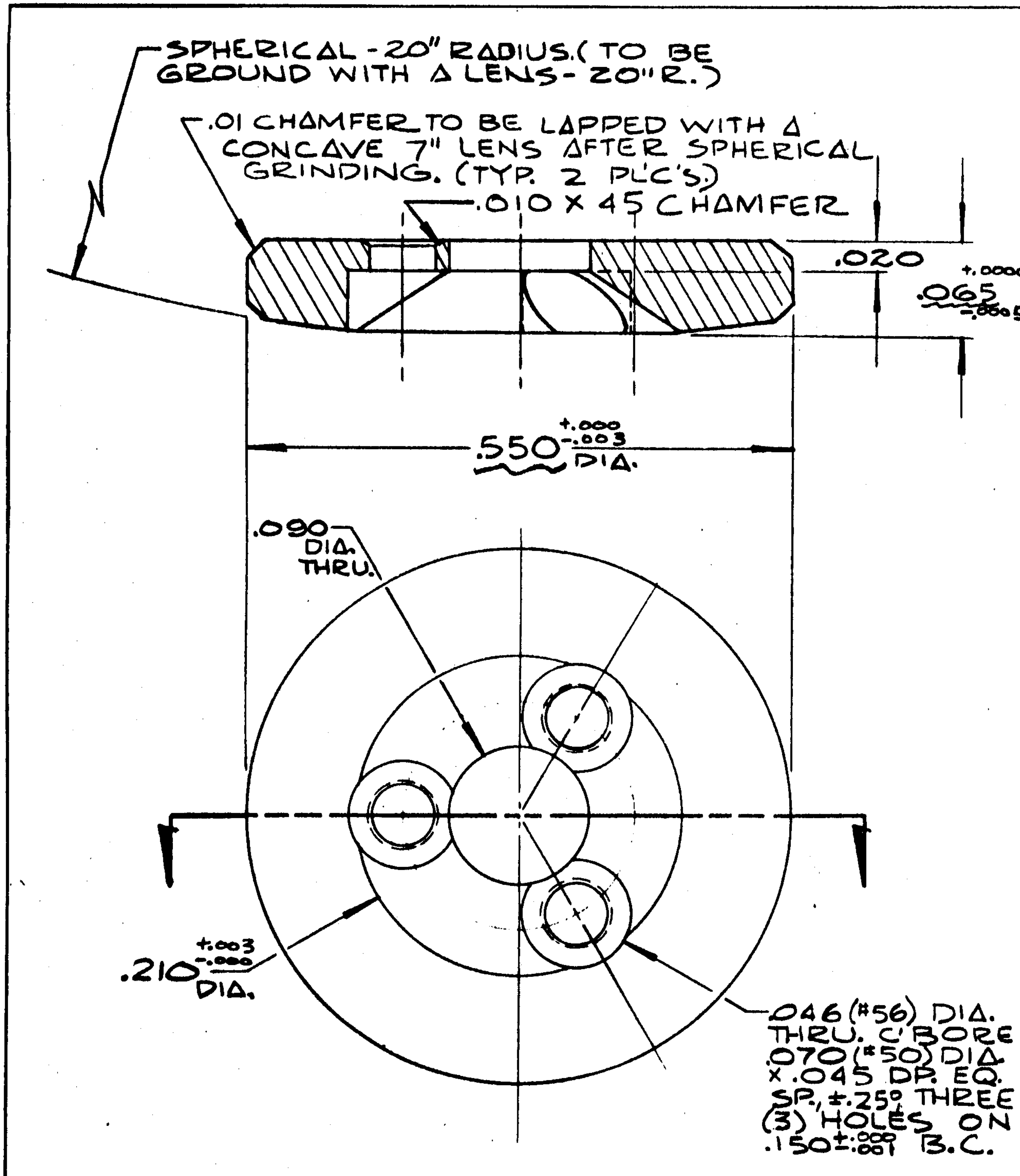
COUPLING ANVIL

SCALE 4:1 | A-11379 | CHG.

NOTES: 1. ALL EDGES 1/64 R.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± 1/2°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. 304 ST. STEEL

FINISH GOLD PLATE

DATE 2·6·64
DWN. KAT
CHK. [illegible]
APP. [illegible]
DATE 2-13-64

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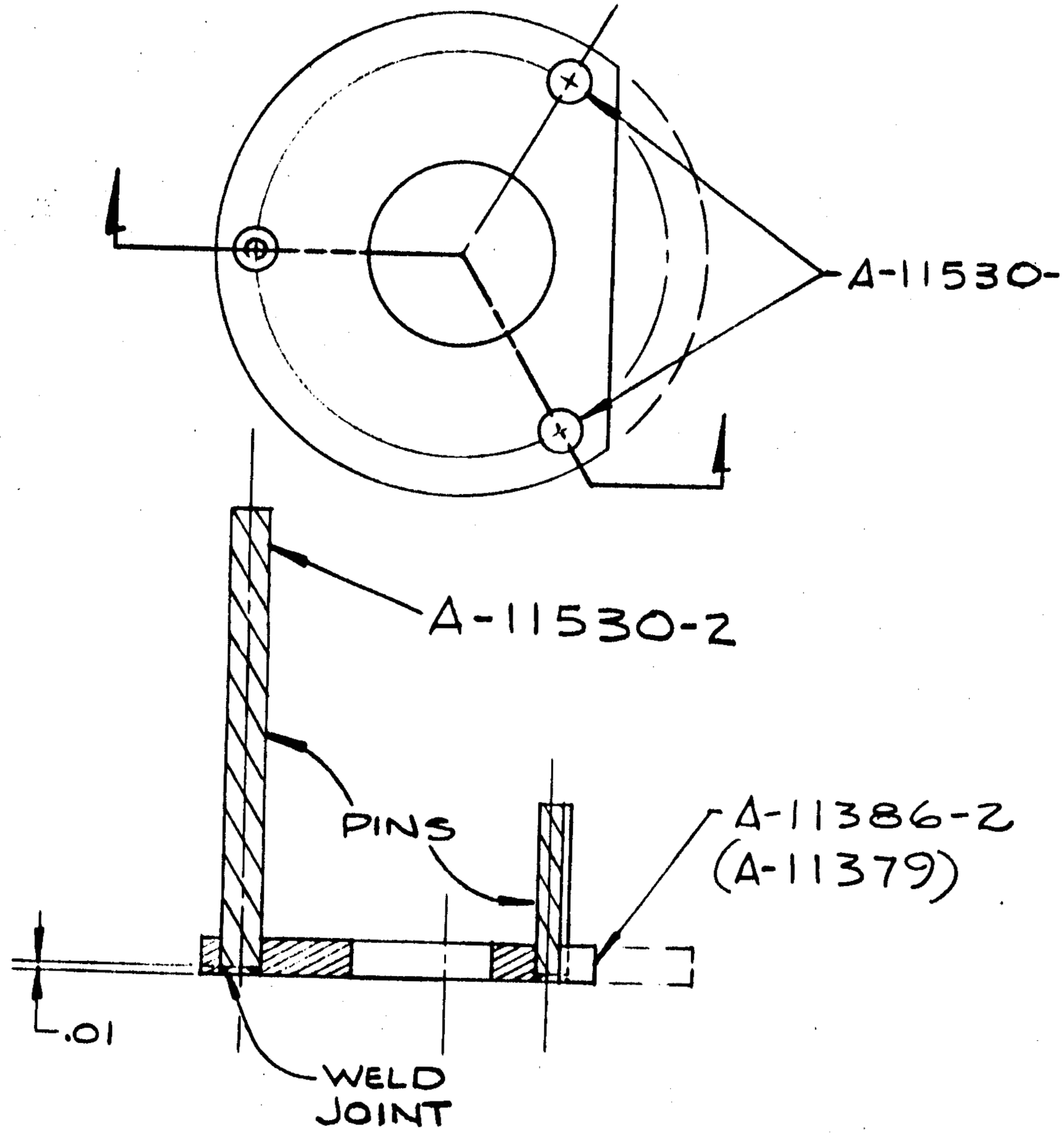
KINELOGIC CORPORATION

PICK-UP ANVIL

SCALE 10·1 | A-11377 | CHG.



2. PART A-11386-2 (A-11379) TO BE FLATTENED ON LATHE AFTER WELDING AND STRESS REMOVING IN NEUTRAL ATMOSPHERE FOR THREE HOURS AT 450°C.

NOTES: 1. PINS HELIARC WELDED TO ANVIL.

REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64	1. CONCENTRICITY .005 T.I.R.
1.00	± .010	2. BREAK ALL CORNERS .015 MAX, .010 MIN.
1.000	± .005	3. THREADS CLASS 2
ANG.	± 1/2°	4. FILLET RADII .010 MAX.
		5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L.	DATE 1·29·64
	DWN. KAT
FINISH	CHK. [signature]
	APP. BB
	DATE 2-10-64

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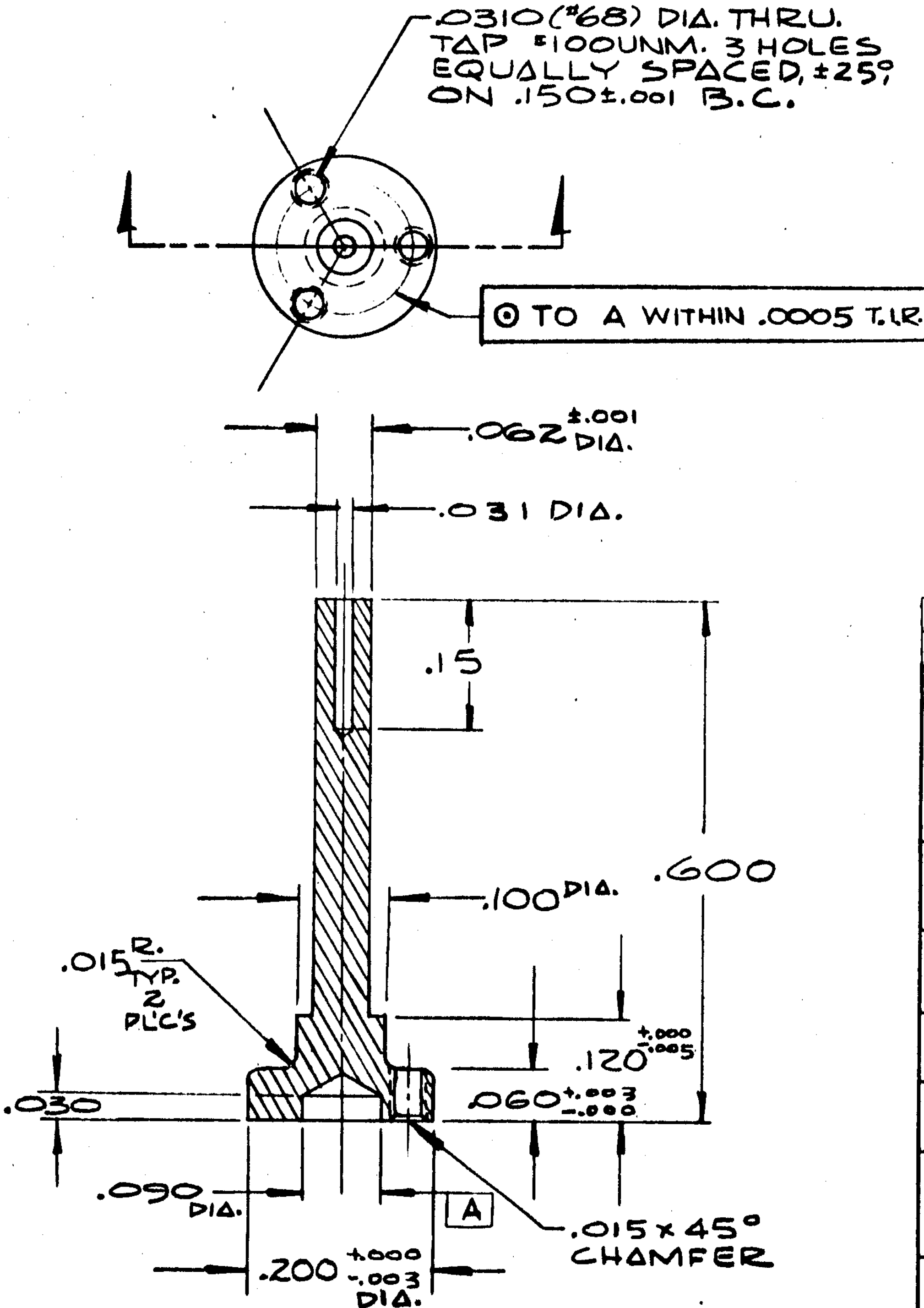
KINELOGIC CORPORATION

PIN & ANVIL ASSEMBLY

SCALE		CHG.
5·1	A-11527	



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE				
NEXT ASS'Y.				

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	±1/64
1.00	±.010
1.000	±.005
ANG.	±½°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. INCONEL X

FINISH

DATE 1·29·64
DWN. KAT
CHK. C.Lu
APP. [illegible]
DATE 2-10-64

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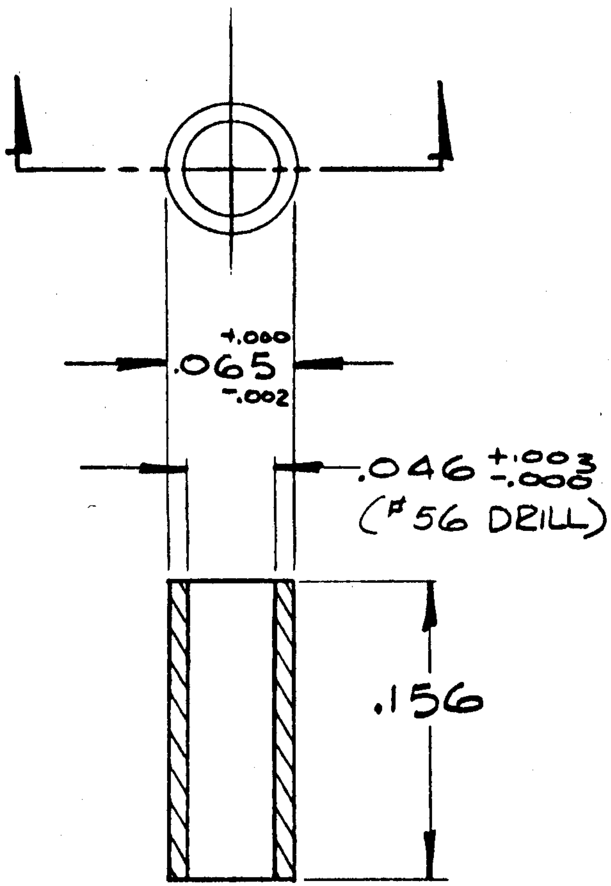
KINELOGIC CORPORATION

CENTRAL PIN

SCALE 5·1 | A-11380-1 | CHG.



REVISIONS

CHG	DESCRIPTION	DATE	BY

TYPE					
NEXT ASS'Y.					

TOLERANCES UNLESS OTHERWISE SPECIFIED

FRAC.	± 1/64
1.00	± .010
1.000	± .005
ANG.	± ½°

1. CONCENTRICITY .005 T.I.R.
2. BREAK ALL CORNERS .015 MAX, .010 MIN.
3. THREADS CLASS 2
4. FILLET RADII .010 MAX.
5. SURFACES 63 MICRO INCH R.M.S. MAX.

MAT'L. INCONEL X

FINISH

DATE 2-13-64
DWN. KAT
CHK. C Lrr
APP. R A Brown
DATE 2-6-64

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KINELOGIC CORPORATION

SLEEVE

SCALE 10:1 | A-11526 | CHG.

ASSEMBLY PROCEDURE

Drawing No.	Name	No. Per Unit		Operations	Parts Used: Dwg. No.	Parts Used: Name	No. Per Unit	Material Used	Tools Used and Storage Devices	Remarks	Quality Control: Control Measure	Quality Control: Instr. Used
C-11529	Driving Assembly	1	1	Presolder Pins	A-11530-3 A-11530-4	Pin Pin	2 1	Cerro #417 Alloy Indium #3 Flux	40w Soldering Iron			
			2	Presolder Pin (1/8 in. of length)	A-11530-2	Pin	1	As Above	As Above			
			3	Washing Pins	A-11530-3 A-11530-4	Pin Pin	2 1	Water and 20% Detergent	Ultrasonic Cleaner	Shake 1 minute at room temperture		
			4	Coating the 3 holes to be soldered	C-11529	Driving Ass'y	1	Indium #3 Flux	#22 Wire			
			5	Heating the Ass'y	C-11529	As Above			Flat 1x1x.2 Iron Plate. 600w Heating Plate.	The ass'y has to be placed with the anvil in contact with the iron plate and heated together. Pins should be introduced after the coating of the body and pushed up to the iron plate		
			6	Coating the 3 holes and the surface B with solder.	C-11529	As Above		#417 Alloy				
			7	Introducing the Pins	A-11530-3 A-11530-4	Pin Pin	2 1	Long nosed Plier				
			8	Cooling the ass'y	C-11529	Driving Ass'y	1		Same as Op. #7. NM120 Tap Pin Vise	Remove the iron plate with the ass'y and cool in air. After cooling, run a NM 120 Tap thru the center hole.		
			9	Washing the ass'y	C-11529	As Above	1	Water and 20% Detergent. Hi purity Deionize water. Dry Nitrogen	Ultrasonic Cleaner. 150-350F in Temp. Controled oven.	5 min. in ultrasonic cleaner, at room temp., with water and detergent(20%). Rinse in running water 30 min. at approx. 100F. 5min in deionized water. Dry with nitrogen at 60psi pressure. Heat in oven at approx. 200F for 30 min.	Measure the insulation res. after drying at 40v (Between anvil and body) Insulation resistance should exceed $2x10^{13}\Omega$. If it is lower, repeat the washing operations.	Keithley Electrometer. Stab. power supply 0-40v.
			10	Polish the Ass'y Surface A	C-11529	As Above	1	Carborundum Grit 300-400-500. AlumOxide Grit 600-800-1000 Keresene Freon.	Flat Optical glass plates Pyrex jar Ultrasonc Cleaner Burrknife	Each grit has to be on another glass plate. Plates should ge checked temporarily if they are not worn out. Between eachpolishing the ass'y has to be put into a jar with clean Freon and shaken one min. in the Ultrasonic Cleaner. After the polishing operation, clean the grounded area on a flat glass plate. The Lapped surface should not be touched by hand. Remove burrs between grit 300 and 400.	Flatness of the surface A should not exceed 3 wave lengths. Insulation resistance should exceed $2x10^{13}$ (see # 9 operation)	Optical Flat Quartz Plate. Same as #9 Carl Zeiss Micrometer 4x Eyeloupe

ASSEMBLY PROCEDURE

Drawing No.	Name	No. Per Unit		Operations	Parts Used: Dwg. No.	Parts Used: Name	No Per Unit	Material Used	Tools Used and Storage Devices	Remarks	Quality Control: Control Measure	Quality Control: Instr. Used
C-11529	Driving Ass'y	1	11	Cleaning the Ass'y	C-11529	Driving Ass'y	1	Freon Dry Nitrogen	Glass syringe 10cc with a #19 Needle, .125 long. Ultrasonic Cleaner. Pyrex 200cc jar (cil) with cover. Flat Plier (Vigor Pl-604) Heating Plate. Tweezer #1 st. st'l. Exicator	Clean with Freon under pressure (syringe) to remove all the metal and grounding particles. Blow with dry nitrogen inside the ass'y. Hold ass'y with pliers. Work in Clean Room. Put ass'y in clean 200cc Pyrex jar. Rinse in Ultrasonic Cleaner for two minutes. (Repeat oper. for total of eight min. using clean Freon each two min.) Use Freon at boiling temp. Avoid removing cover after cleaning. Seal the ass'y in a clean glass exicator placed in the clean room.		
C-11528	Pick-up Ass'y	1	12	Polishing the Ass'y Surface A	C-11529	Pick-up Ass'y	1	Same as # 10	Same as #10	Same as #10	Flatness of surface A Should not exceed three wavelengths after polishing. Insulation resistance at 40v should be better than $2 \times 10^{14}\,\Omega$ for Body-Center Pin, and better than $2 \times 10^{13}\,\Omega$ for the Body-Anvil. No scratches	Same as #10
			13	Gold Plating of anvil and center pin surface A	C-11529	As Above	1		Tweezer #1 St. St'l Tweezer #7 St. St'l Exicator	To be performed by Inland Electronics. Gold plated surface should not be touched by hands. Seal gold plated ass'y in the exicator.	Hi-purity neutral gold plating. Body should not be plated. Thickness of the gold layer should be approx. .00001 in. To be plated together with Membrane A-11383, Anvil A11377, Screw 1, 20 UNM x .312. Check the insulation resistance after plating. (Should be the same as #12)	Same as #9
			14	Polishing the Gold plated surface A	C-11529	As Above	1	Alum. Oxide, grit 1000. Kerosene Freon	Flat Optical glass plates. Pyrex Jar. Ultrasonic Cleaner. Exicator.	Polish on glass plate with Oxide, Grit 1000 and Kerosene. Rinse in clean Freon and Ultrasonic Cleaner. Polish on clean glass plate. Rinse in Freon. Seal in the Exicator.	Visual inspection of the gold plated surface.	

ASSEMBLY PROCEDURE

Drawing No.	Name	No. Per Unit	Operations		Parts Used		No. Per Unit	Material Used	Tools Used and Storage Devices	Remarks	Quality Control	
					Dwg. No.	Name					Control Measure	Instr. Used
C-11528	Pick-up Ass'y	1	15	Cleaning the Ass'y	C-11529	Pick-up Ass'y	1	Same as #11	Same as #11	Same as # 11		
	Central Screw, 1.20 UNM x .312, 303 St. St'l Fillister Head	1	16	Adjusting the Head Diameter.		Central Screw	1		Lathe and 1.20mm Collet.	Reduce head dia. to .0750 dia. ± .0001. Leave the bearing corner sharp, remove burrs. Concentricity= .0002T.I.R.	Measure Diameter, Concentricity. Visual inspection; Bearing edge should be sharp and clean.	- Carl Zeiss - Micrometer 4x eyeloupe Dial Indicator with support.
			17	Polishing the Bearing Surface		As Above	1		Flat Lucalox plate with a 1.22 dia. hole thru. Watch-makers screw driver, Boley style blade (2mm)	Put screw in hole in Lucalox plate. Press and turn screw with screwdriver in clock & counterclockwise directions until bearing surface becomes flat.	Visual inspection of bearing surface flatness and bearing edge	4x eyeloupe
			18	Gold Plating		As Above	1		Tweezer #7 St. St'l Exicator	Same as #13	Hi-purity neutral gold-plating. Gold layer to be approx. .00001 thick. Plate Pick-up Anvil A-11377, Membrane A-11383, Pick-up Ass'y C-11529 together with Central Screw.	
			19	Polishing the Bearing Surface.		As Above	1	Same as #14	Same as #17. Tweezer #7 St. St'l. Pyrex Jar. Ultrasonic Cleaner. Exicator.	Same as #17	Same as #17	Same as #17
			20	Cleaning the Screw		As Above	1	Same as #11	Same as #11 except Flat pliers are not used.	Same as #11		
A-11383	Membrane	1	21	Polishing	A-11383	Membrane	1	Alum. Oxide Grit 800-1000 Kerosene Freon	.55dia. x .125 thick steel disc with flat surface. Flat optical glass plates. Pyrex Concave loupe 7in. focal distance. Ultrasonic Cleaner.	Polish the Membrane on a flat glass with grit 800 and kerosene until the entire surface becomes uniform. (Use steel disc to press against membrane while polishing) Polish both sides. Polish the chamfer on one side using the 7in. focal distance loupe, grit 800. Rinse in Freon in Ultrasonic Cleaner. Repeat all operations with grit 1000. Rinse in Freon, polish on clean ground glass. Rinse again in Freon	Flatness	Carl Mahr Dial Indicator

60

ASSEMBLY PROCEDURE

Drawing No.	Name	No. Per Unit		Operations	Parts Used		No Per Unit	Material Used	Tools Used and Storage Devices	Remarks	Quality Control	
					Dwg. No.	Name					Control Measure	Instr. Used
A-11383	Membrane	1	22	Gold Plating	A-11383	Membrane	1		Same as #13	Same as #13	Same as #13, Except Insulation resistance	
			23	Polishing the Gold-plated Membrane	As Above	As Above	1	Same as #14	Same as #14 Steel Disc (See #21)	Same as #14	Same as #14	
			24	Cleaning the Membrane	As Above	As Above	1	Same as #11	Same as #20	Same as #11		
A-11377	Pick-up Anvil	1	25	Polishing	A11377	Pick-up Anvil	1	Same as #10	Flat Optical Glass Plates (One for each grit.). Concave 20in radius lens. Concave 7in. radius lens. Pyrex Jar, 200cc. Tweezer #7 St. St'l/ Ultrasonic Cleaner.	Polish the spherical surface with a 20in. rad. lens and grit 300. Polish the flat surface on a flat glass plate Chamfer the edges with a 7in. rad. lens. Rinse in Freon. Repeat operation with each grit. After last Freon rinse, polish on a clean ground glass plate or lens.	Flatness should not exceed 3 wave lengths on flat surfaces. Heigth variation on spherical side not to exceed 1.2 mils ±.0002.	Optical flat Quartz plate. Carl Mahr Dial Indicator.
			26	Gold Plating	As Above	As Above	1		Tweezer #7 Exicator	Same as #13	Hi-purity neutral gold plating. Gold layer to be approx. .00001thick. Plate with Membrane A-11383, Pick-up ass'y C-11529, Screw 1.20unm	
			27	Polishing the Gold Plating	As Above	As Above	1	Same as #14	Same as #25	Same as #25, except use 1000 grit and clean plate and lens.		
			28	Cleaning the Pick-up Anvil	As Above	As Above	1	Same as #11	Same as #20	Same as #11		
	Shield Ass'y		29	Brazing the Copper Tubing	B-1184-1 A-11533	Shield Tubing	1 1	Handy Harman easy flow #3 wire. Handy Harman flux Bl	Temperture Controlled Electric Furnace. Long nose pliers. 2x2x.25 Steel Plate.	Heat furnace to 1350F. On joint between tube &shield apply a ring of Easy Flow #3wire .09 I.D. & apply flux over it. Put on steel plate and push slowly into furnace. Remove ass'y & steel plate when silver flows. Cool in open air.	Visual inspection of the brazed joint.	
			30	Remove the silver excess		As Above	1		Chamfer burrs.	Remove all silver from the edge and internal areas of of the shield.	Visual inspection	
			31	Liquid Honing		As Above	1			To be Performed outside		
			32	Cleaning		As Above	1	Same as #11	Same as #1	Same as #20	Visual Inspection	

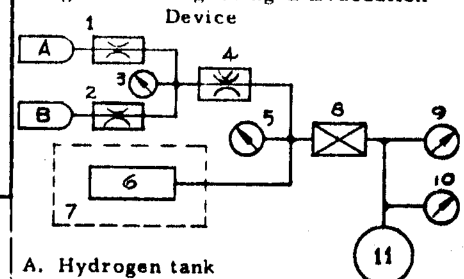
ASSEMBLY PROCEDURE

Drawing No.	Name	No. Per Unit	Operations	Parts Used: Dwg. No.	Parts Used: Name	No. Per Unit	Material Used	Tools Used and Storage Devices	Remarks	Quality Control: Control Measure	Quality Control: Instr. Used
C-11387-1	Dynamic Capacitor		33 Assembling the Driving Side (See note #1)	C-11529 A-11383 A-11388-3	Driving Assembly Membrane 1.2 0UNM Screw Washer#3	1 1 1 2	Dry Nitrogen Freon Epoxy Hysol R9-2039/H2-3561	Special assembling support with screw & allen wrench. Tweezers, #1 and #7 st. st'l. Screwdriver Boley type with2mm blade. Clean room Exicator Syringe with #19 needle (cut to .125in) Clean Glass Plate. Center'g ring Temperture Controlled Oven. All tools to be cleaned in Freon before using.	Put Driving Ass'y in support and tighten support until Ass'y is secure. Place 1.20unm scr. on glass plate in vertical position. Place membrane over screw with chamfer side up. Place a small amount of Epoxy in hole around screw. Add two washers and place this assembly into position over driving ass'y. Remove dust or lint from anvil and membrane. (Do not use Freon to clean membrane.) Use centering ring to center the membrane and tighten the center screw. Remove ring. Remove Ass'y from support for inspection. Place in the exicator for 24hrs. storage. After storage, heat for two hours at +90°C. Tighten the center screw. Inspect.	Capacitance between driving anvil and membrane should be 22.5 $\pm$2.5pf. Visual inspect the air gap between the membrane and anvil. (Should be parallel). Repeat both checks after 24 hours.	4x eyeloupe. Narconi Univ. Bridge
			34 Assembling the Pick-up Side (See note #1)	C-11528 A-11377 A11388-2	Pick-up Ass'y. Pick-up Anvil. 1.00UNM Fillister H'd Screw .080 long 304st. st'l Gold Plated Washer#2	1 1 3 1	Same as #33	Same as #33 Screwdriver Boley type with a 1.4mm blade.	Place Pick-up Ass'y in the Ass'y support. Put a spacing washer over the central pin. Put Pick-up Anvil in place. Screw three 1.00unm screws into place, but do not tighten to maximum. Inspect airgap. Remove lint or dust with jet of Freon or dry nitrogen. tighten screws. Inspect ass'y. Store in exicator 24hrs. Heat 2hrs at +90°C. Re-tighten screws. Re-inspect.	Capacitance between coupling anvil and Pick-up should be 55 $\pm$5pf. Visual inspection of the airgap between the anvil and membrane. Repeat both inspections after 24 hours.	4x eyeloupe. Marconi Univ. Bridge.

ASSEMBLY PROCEDURE

Drawing No.	Name	No. Per Unit		Operations	Parts Used: Dwg. No.	Parts Used: Name	No. Per Unit	Material Used	Tools Used and Storage Devices	Remarks	Quality Control: Control Measure	Quality Control: Instr. Used
C-11387-1	Dynamic Capacitor		35	General Assembling (See note #1)	See #33 See #34 A-11376 A-11388-1	Driving Side Pick-up Side Ring Spacer Washer #1 1.20UNM .275 long Fillister H'd Screw 000 Lock Washer Shield Ass'y	1 1 1 as req'd 6 6 1	Same as #33 2" wire #22 60/40 soft solder alloy and rosin core	Same as #33 40w Soldering Iron	Place Pick-up Ass'y in the Ass'y support. Place Ring, spacer, over Pick-up and Driving Ass'y over Ring. (Inspect position of terminals. See drawing.) Place 000 washers on the 1.20unm screws and screw to locking position. Inspect. Heat Ass'y two hours at +90°C. Re-lock screws. Re-inspect. Insert into the Shield Ass'y. (Attention to the position of terminals in respect to the evacuation tube. See Drawing.) Solder the ground wire to the central screw.	Capacitance between Pick-up Anvil and the ground should be 55pf, +5. To correct capacitance, lapp the Spacer Ring, see#23 or #24, or add washer #1 as needed. Measure insulation resistance between ground and Pick-up anvil. It should be 2.5x 10^{14} ohms. (with coupling capacitor grounded) Put Ass'y in small vacuum chamber to measure the efficiency and contact potential. Membrane should clash on pick-up at over 15% efficiency.	4x eyeloupe. Marconi Univ. Bridge. Keithley Electrometer. 0-40v regulated power supply. 2 stage vacuum pump. Small Vacuum chamber. VTVM Millivoltmeter (for A.C.) A.F. Generator Device to test efficiency and contact potenti[al] 0-300v regulate[d] power supply.
			36	Welding the Edges					Copper Heat Sink.	Heliarc Weld	Helium leakage test: Leakage smaller than 10^{-10}cc/sec. to be performed outside.	Mass spectrometer for heliu[m] dector.
			37	Outgassing and evacuation (See note #3)				Argon Hydrogen 60/40 soft solder, alloy and rosin core.	See Diagram of Outgassing and evacuation device. (Qual. Contr.) Pliers, (pinching). Soldering Iron.	(See note below)	Diagram of Outgassing & Evacuation Device	

Diagram of Outgassing & Evacuation Device



A. Hydrogen tank
B. Argon tank
1. Pressure regulator valve 2000/10-10
2. " " " " "
3. Pressure gage, 0-100psi
4. Micrometer valve
5. Vacuum gage, 1 minium (Termoc.)
6. Dynamic Capacitor
7. Temp. controlled oven. 50-250°C
8. Vacuum valve
9. Vacuum gage, 1 minium (Termoc.)
10. Hi vacuum gage, .01 min. (10n.)
11. 2 stage vac. pump (Mec. + Diff.)
Stopwatch

Notes: (Remarks on Outgassing and Evacution.)

Soft solder the evacuation tube of Dynamic Capacitor to Evacuation system. Put Dyn. Cap. in cold oven. Open valves 8 and 4. Start roughing pump until gage shows 20μ. Run pump for 1/2 hr. Set oven at 135°C. Run system 1/2 hr. Close valve 4 and adjust regulator until the pressure reaches 30 psi. (gage 3). Close valve 1 and open valve 4 until gage 5 reaches 5μ. Close valve 4 and adjust regulator until pressure on gage 3 is 10 psi. Open valve 4 gradually until vacuum, gage 5, stabilizes at 100μ. Run system 5 hrs at 135°C. Close regulator 1 and open, completely, valve 4. Wait until vacuum, gage 5, reaches 5μ. Close valve 4 and adjust regulator 2 (Argon) until pressure 3 is 30psi. Close valve 2. Start diffusion pump. After vacuum reaches approx. .5μ, gage 10, close valve 8 and measure, with the stop watch, the time taken for vacuum 5 to decrease to 50μ, (outgassing time approx. 5 sec.). Open valve 8. Repeat outgassing time measure after approx. 6 hours. Outgassing will be considered ready when the measured outgassing time is 30 times longer than the first one. (Time fromthe moment the valve 8 is closed until the vacuum 5 decreases to 50μ.) Close valve 8. Open, completely, valve 4 and 2 and leave Dynamic Capacitor under 30psi Argon pressure for 30 minutes. Close valve 4 and open valve 8. When vacuum gage falls to 0, measure the outgassing time. (approx 3 sec.) Check outgassing time periodically. Evacuation is ready when the timeof outgassing is 100 times longer than the first timing. Remove Dynamic Capacitor from oven and pinch evacuation tube with pinching pliers. (Pinch approx. 1/2in. from shield.)

ASSEMBLY PROCEDURE

Drawing No.	Name	No. Per Unit		Operations	Parts Used: Dwg. No.	Parts Used: Name	No. Per Unit	Material Used	Tools Used and Storage Devices	Remarks	Quality Control: Control Measure	Quality Control: Instr. Used
			38	Mounting the Magnetic circuit	A-11536 A-11525 A-11535 A-11534	Base, Magnet Coil Cover, Magnet Magnet, Alnico 5, .140 dia, x .250 Label Plastic Bag	1 1 1 1 1 1	Epoxy Rosin Ecocoat C26	Tweezers, #1 and #7 st. st'l Temperature controlled oven "C" clamp Emery cloth 240 grit	Slip magnet into the coil, and attach the Base to the end oppsite to terminals, with epoxy, and clamp together with "C" clamp. (Epoxy coil to Magnet also) Place ass'y in oven for two hours at +70°C. After cooling, clean faces of poles with emeri cloth. Epoxy ass'y to pin, A-11530-4, and mount cover, A-11535. The magnet should make contact with the cover, not the coil. Fill any space between the coil and cover with epoxy. Fill space between the coil and the two parallel pins, A-11530-3. Heat in oven 2 hours at +70°C. Make the final inspection, glue on the label. Pack in a plastic bag.	The resistance of the magnetic coil should show 450±5% on VTVM when set on ohm scale. Insulation resistance between terminal of magnetic pick-up and ground should be larger than 500 megohms. Insulation resistance between Ground and Pick-up Anvil should be larger than 2.5 x 10^{14}, with coupling anvil grounded. Resistance between ground and coupling anvil and between ground and driving anvil both are 1 x 10^{13}. Measure efficiency and contact potential	H. P. VTVM Keithley Electrometer. 0-40v regulated power supply. A. F. generator V.T MVM. 0-300v regulated power supply. Contact potential and efficiency device.

NOTES:

1. Operations 33, 34, and 35 should be made in clean room only.
2. Do not handle parts by hand. All tools used during operations 33, 34 and 35 must be rinsed in Freon.
2. The dry nitrogen tank is equipped with a pressure regulator. (0-100psi); rubber hose and a quick relief valve.
3. Operation 37 must be completed uninterrupted. If it is stopped for any reason, close the valve 8 , open valve 4 , and leave the device under 30psi pressure using the same gas that happened to be in the device at time of interuption. Leave oven at 135°C .